Reconstruction of Industrial Residential Buildings Built in the 1950s–1970s with Application of Modern Wooden Structures

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Abstract. A substantial part of the dwelling stock in the Russian cities and towns was built in the period of 1960s and 1970s. In the circumstances of the deficient territorial resources in many cities, the need to renovate the post-war residential constructions of the initial period in the industrial construction of dwelling houses is considered as one of the major vectors in providing the dwelling facilities for the citizens. Basing on the analysis of the modern methods, the authors draw the conclusion that the possibility to realize the renovation programs is available only in the capital cities, where the land is highly attractive in terms of investments. As far as regions are concerned, it would be more adaptive and more beneficial to choose the option of the comprehensive reconstruction. The authors also considered such question as whether it would make sense to proliferate the international experience of applying the new technologies and the modern wood-based structures in reconstruction of buildings. This measure would make it possible to resolve not only the practical, but as well the ecological and architectural plus esthetic tasks in renovation of the existing standard buildings, to raise the status and profitability of the standard dwelling buildings and to reduce the ultimate cost of the reconstruction. Basing on the conceptual project for renovation of a mini-district in the central part of Irkutsk, the authors have demonstrated the possibilities of reconstructing the dwelling quarters with the use of modern technologies for the wooden housing construction.

1. Introduction

In the European countries about a half of the dwelling stock is represented by the historical buildings of the late 19th–early 20th centuries. The dwelling stock of the Russian Federation is rather young as 80% of it was built after the 1940s. In the post-WW2 years, the civil construction in the Soviet Union, following the suit of European countries, reached the industrial level in the dwelling-house construction. In the period from 1956 through to 1963, the country made a breakthrough in development and mastering of the constructive solutions, owing to which it became possible to resolve the acute problem of deficient dwelling space within the record-bearing short time and with the minimal level of costs. Within 9 years, 25% of the country population moved from basements and barracks to the separate apartments, which were given to citizens free of charge [1]. Meanwhile, the level of engineering equipment was higher than the one in the municipal dwelling houses of many European countries. The construction of economical small-space houses for individual families’ settlement directly reflected the socio-economic development of the country, as well as its mode of life, everyday living, and culture. Today, too, the considerable portion of the dwelling stock in cities
and towns of the RF (especially in its regions) dates back to the period of construction in the 1950s–1970s.

2. Timeliness
The standard dwelling houses of the afore-specified period were constructed in the two categories, such as: “the first category of endurance” with the estimated life of up to 70 years, and – for the temporary resolution of the housing problem – for 25 years. The physical deterioration of the buildings in the “the first category of endurance – non-destroyable series” today accounts for some 20%, and these buildings are featured by a substantial reserve of the bearing capacity, which has been confirmed by the multiple examinations and surveys [2]. The latter circumstance can be explained by the imperfect calculation methods for the constructions (the actual solidity of concrete normally is 1.5–2 times higher than the estimated one). Therefore, the life cycle of the “non-destroyable series” can be prolonged up to 100 years. However, because of the functional obsolescence (over 80%) (the volume-planning solutions being not in compliance with the current norms, wear and tear of the engineering equipment, and low ceilings), as well as the commonplace construction of the mini-districts require to modernize and reconstruct such dwelling stock [3].

The constantly growing share of the underdeveloped dwelling stock causes the negative impact on realization of the housing policy oriented to the better provision with the dwelling facilities and to improvement of the residence conditions for the population. The architectural environment of the post-war standard constructions, being perceived today as non-differentiated and non-expressive, does not meet the requirements of the modern city and needs to be renovated. As a result of the type-design practice applied in the architectural solutions, in the regions with different cultural, climate, and historic specifics the impersonal dwelling houses were constructed, which today need to be renovated. The problem of the environment degradation inevitably leads to aggravation of psychological problems and social conflicts. At the same time, attractiveness of territories in the central and buffer parts of a city, where the standard bearing-wall houses have been constructed, is connected with the high-level transport access and transport availability, widely-developed infrastructure, high-density planting of greenery and the high potential for its densification, what is extremely important in the circumstances of deficient territorial resources applicable for the new construction. All these factors require renovation of the dwelling houses that were built in the initial period of the industrial dwelling construction.

3. Theoretical basis
Today we may emphasize the three major vectors, the selection of which would depend on the resources and potentials of a specific region [4, 5, 6, 7, and 8] – such as: capital repair, renovation of the buildings, and the comprehensive reconstruction. The dwelling stocks volumes being in need of the capital repair as a result of the violated service regulations, deficit of financing, and natural tear and wear are growing year by year, and to bring such dwelling houses in compliance with the currently effective norms only by means of the capital repair would require the substantial financial expenditures. Meanwhile, there will be no principal change in the volume-planning and architectural indices of the buildings and the entire quarter.

The renovation programs, developed for many major cities of Russia (Moscow, Saint-Petersburg, Vladivostok, as well as for the Irkutsk, Samara, and other oblasts), would require the tremendous expenditures [9, 10, 11, 12]. These programs make provisions for destruction of 4-5-storey houses to be replaced by new multi-floor dwelling, or for partial reconstruction of the post-war dwelling stock, as well as for the measures to be taken in order to renovate the environment of the public space. Only the destruction of the building and utilization of the respective wastes account for one third of the reconstruction price, and meanwhile it is necessary to take into consideration the therewith connected ecological problem [4]. In the circumstances of unavailable substantial financial support, the complex for destruction of the five-floor houses and construction of the new dwelling houses in the regions for
the given moment is impossible and can be realized mainly in the capital cities with the high-rate investment attractiveness of the land spaces.

In the context of the broad diapason of opportunities for renovation of the dwelling quarters, the comprehensive reconstruction of the dwelling stock may be considered in the circumstances of deficient territories for the new construction as an important vector of providing the citizens with the comfortable social dwelling. The comprehensive reconstruction techniques contain the broad spectrum of opportunities for improvement of the volume-planning parameters of dwelling houses and the whole five-floor quarter, and offer the more adaptive and more beneficial method of renovation for the regional cities. However, as demonstrated by the practice, quite often the comprehensive renovation is reduced to resolution of the utilitarian problems, such as replacement of the façade-facing materials and construction of the attic floor, which would not resolve the tasks of forming the modern architectural environment.

Reconstruction of dwelling houses includes a rather broad diapason of the possible measures, which in terms of their scale may be divided by the following groups (Fig1):

- **L** – the ones that densify the volume of construction (various types of inserted buildings, annexes, and secondary construction make it possible to increase the height of the house through to 10-12 floors [13]);
- **M** – the ones that increase the space and volume of the building (1-2-floor top-out relying on the existing constructions, construction of mansard truss roofs, extension of the body frame, and fragmental annexes);
- **S** – the ones that make the residence more comfortable (transformation of balconies into the window bays, arrangement of elevator shafts, and the yards attached to the first-floor apartments).

Application of the afore-presented reconstruction techniques would allow to find a new volume-plastic compositional solution for the façade, or to stylize the latter so that it would match the architecture in the given region.

![Figure 1. Reconstruction techniques: densifying the volume of construction (L); increasing the space and volume of the building (M); and, making the residence more comfortable (S).](image-url)
Today the five-floor dwelling stock is under being reconstructed active both in the RF and abroad [14] (Fig. 2).

RF, Moscow, 2017: Reconstruction techniques: secondary construction, butt-end annex, adding of the elevator, fragmentary extension of the body structure; compositional solution for the facade: voluminous-plastic.

RF, Kaliningrad, 2017:
Reconstruction techniques: adding the attic floor, re-planning of the first floor for the public functions; compositional solution for the facade: stylization, in the “Hanseatie” style.

France, Lorient, 1980:
Reconstruction techniques: build-up of floors, adding the window-bays, fragmentary removal of floors, construction of new body structures; compositional solution for the facade: voluminous-plastic.

Germany, Leinefelde, 1999:
Reconstruction techniques: adding of balconies and loggias, arrangement of private yards; compositional solution for the facade: voluminous-plastic.

Figure 2. Examples of the Realized Reconstruction of Five-Floor Buildings.
4. Materials and methods
At the present time, the dwelling buildings use to be reconstructed with application of reinforced concrete, stone, and metal constructions. The exception is made for arrangement of attic floors with wooden rafter constructions.

In the real-estate markets of the countries of Europe and America, the demand is growing for the ecologically clean, economical, and energy-saving solutions. Invention of water-proof polymer and epoxide glues, which sharply improve the quality of the original timber, made it possible to devise the modern technologies for introduction of lined wooden constructions (the quality of which is improving continuously) in the multi-floor (12-15 floors) construction. In the nearest future, the wooden house construction can become one of the most promising vectors in the sphere of construction [15, 16], which is especially topical for the countries with the rich stocks of forests.

Notwithstanding the similarity of the climate conditions, wood is being used in construction within Russia 20-times as less than in Finland or Sweden, and its use takes place actually only in the limited segment of the private sector. This fact can be explained by the RF norms for the wooden construction: the height of the building may not exceed 5 meters, and the space must be within 500 square meters. However, following the global trend of using the ecologically clean timber in the multi-floor construction, as well as taking into account the enormous potential of the Russian timber-industry complex, the RF Ministry of Construction plans to build up the use of timber in the housing construction by 20% [17]. With introduction of the new technologies, it will be possible to reduce the period of the houses’ construction owing to high-extent of readiness of plant-manufactured elements and to easiness of the assembly. Today, drafting of the new regulations is underway, which would take account of the possibility to apply the modern wooden constructions – such as the CLT-panels (cross-laminated timber – the multi-layer lined wooden panels) and the LVL-carcass (laminated veneer lumber – the lined skillet constructions), and meanwhile the production base is being expanded in the regions with abundant forest resources [18]. The quota, being planned for introduction of such constructions in the building of public facilities as well as houses for the people to be re-settled from the shabby dwelling stock, amounts to around 30%.

Proliferation of the experience of applying the new technologies of the modern wood-based constructions for reconstructions of buildings would make it possible to resolve both the practical as well as the ecological and architectural-esthetic tasks of renovating the existing standard construction, raising the status and profitability of the standard dwelling buildings by means of their architectural novelty, as well as reducing the ultimate value of the reconstruction.

The modern timber constructions have a number of important advantages [19, 20] – such as: light weight, allowing to use the miniature equipment and just insignificantly to increase the loads on the basis and foundations in case of the built-up floors; high solidity characteristics; low thermal conductivity; fire-resistance in the diapason of REI 30-120; and, the high ecological properties of the material. The possibility to make the outer constructions the weather-resistant expands the spectrum of architectural solutions for facades, while the high degree of the manufactured readiness of constructions makes it possible to effect reconstruction within short periods of time even in the regions with high seismic activity.

Today, the Russian and world-wide practice of reconstruction of dwelling buildings at the stage of designing and realization demonstrates a substantial number of good cases in point of using the modern wooden constructions (Fig. 3).

5. Practical significance of the proposal
In the National Research University of the MGSU, within the framework of a Master’s thesis, the conceptual project was drawn for renovation of the mini-district of the 1960s in Irkutsk (included in the list of Russia’s historic settlements). The typology analysis of the wooden architecture as well as the regional modernism period [24, 25] enabled the author of the given project to find out the most typical architectural forms and to propose realization thereof with application of the modern
technologies for the wooden-house construction (CLT и LVL), which is very organic for the region of Irkutsk.

For renovation of the mini-district with its brick-laid and bearing-wall 5-floor houses, the following set of the reconstruction elements (built-up floors, annexes, bilateral extension of the body frame) was selected:

- On the buildings deeply within the quarter, the two-floor attics have been built up, with penthouses and green gardens on the upper floor;
- The buildings located along the main street of the quarter have been reconstructed by means of the added bay-windows, which form the expressive street-looking façade of the construction;
- For the buildings deeply within the quarter, the technique of the bilateral extension of the body frame was applied, which reflects the principle of forming the voluminous plastic of the façade by means of the simple articulated forms of the regional modernism.

Architect: Nikita Yavein
Location: Russia, Saint-Petersburg
Years: 2006–2009
Function: office
Material: LVL
Status: realized
Elements of reconstruction: the attic floor [21]

Architect: Shigeru Ban
Location: Switzerland, Zurich
Year: 2009
Function: office
Material: LVL
Status: realized
Elements of reconstruction: (1) the attic floor, (2) the butt-end annex [22]
Architect: Robert Davidson
Location: England, Camberwell
Year: 2018
Function: dwelling house
Material: LVL
Status: project

Elements of reconstruction: (1) the attic floor, (2) broadening of the body frame [23]

Figure 3. Examples of using the modern wooden constructions for reconstruction purposes.

Figure 4. Example of the Dwelling-Quarter Reconstruction in Irkutsk with the Applied Modern Technologies for the Wooden Housing Construction.
6. Conclusions
(1) In the circumstances of deficient territorial resources in most of the RF cities, renovating the post-war dwelling buildings, constructed industrially in the 1960s and 1970s, has to be seen as one of the major vectors in providing the citizens with dwelling facilities.

(2) The dwelling stock can be brought into compliance with the modern norms by means of realizing the renovation programs, and this can be done only in the capital cities with the high investment attractiveness of the urban lands. As for the regions, the most adaptive and beneficial method for renovation of the constructed quarters is the comprehensive reconstruction offering the broad spectrum of opportunities for improvement of the volume-planning parameters of five-floor houses and the quarters at large.

(3) Following the global trend of applying the ecologically clean timber in the multi-floor construction, as well as taking into account the available enormous potential of the Russian timber-industry complex, today the development of the updated sets of regulations in underway in the RF, which regulations would take into account the possibility to apply the modern technologies for the use of the modified timber-based constructions, as well the production base is expanding.

(4) Proliferation of the experience, accumulated in construction of multi-floor buildings with the use of timber construction, to the sphere of reconstruction will make it possible to expand the visual variety of the existing architectural environment that features the quarters of mass standard construction as built in the 1960s and 1970s.

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