The Use of Effective Design Solutions and High-Tech Building Materials for Reconstructing Residential Buildings of Mass Development in 1960-1990

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Abstract. In connection with the mass development of large-panel typical buildings, in solving the problem of housing for millions of people in the country, they were supposed to be limited in use for 50-60 years. However, the solution to this problem occurs mainly in Moscow, since significant investments are required to resolve the issue of demolition, relocation of residents and the construction of new buildings on the site of the demolished ones. A method of reconstruction of these objects is proposed with the solution of the issues of thermal modernization of facades and improvement of sanitary and hygienic living conditions, with the involvement of investors without the use of budgetary funds [1].

1. Introduction
The massive development of a model series of apartment buildings, so-called "Khrushchyovka" in 60-90 of the last century in the most cities of the Soviet Union solved the problem of optimal housing for the most families.

Figure 1. Mass development of typical series of residential buildings.
However, at present, when these buildings have served their standard period, there was a problem of their utilization, or reconstruction, taking into account the level of wear, large heat losses, low “quality of life” due to poor living conditions (temperature and humidity conditions of rooms, poor air exchange, combined toilet rooms, small-sized common areas, etc.) [2].

2. Proposed Solutions
The main indicators of "quality of life" from the standpoint of a healthy lifestyle include the following criteria, according to sanitary and hygienic requirements: normalized temperature difference, humidity in residential premises, distribution of air flow to ensure the required air exchange.

The most important of them is the observance of the requirements of the standardized temperature difference of temperatures for the various structural elements of the building on their inner surface and the temperature inside the room, Table 1.

Table 1. Requirements of the standardized temperature difference of temperatures for the various structural elements of the building.

| Buildings and premises                                                                 | Normalized delta, $\Delta t$ °C, for exterior walls and attic coverings | overlaps over driveways, basements and undergounds |
|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------|
| Housing, health care and child care facilities, schools, boarding schools             | 4,0                                                                      | 3,0                                              | 2,0                                              |

Also one of the important indicators is the control of humidity of the premises, in accordance with the temperature of the dew point on building structures, Table 2.

Table 2. Humidity in residential premises.

| Dew point, °C | Human perception                                            | Humidity (at 32 °C), % |
|---------------|-------------------------------------------------------------|------------------------|
| More than 26  | extremely high perception, deadly for asthma patients       | 65 and above           |
| 24—26         | extremely uncomfortable condition                            | 62                     |
| 21—24         | unpleasantly perceived by most people                       | 52—60                  |
| 18—21         | unpleasantly perceived by most people                       | 44—52                  |
| 16—18         | comfortable for most, but there is an upper limit of humidity | 37—46                  |
| 13—16         | comfortable                                                 | 38—41                  |
| 10—12         | very comfortable                                            | 31—37                  |
| Less than 10  | a bit dry for someone                                       | 30                     |

Unfortunately, the parameter “air exchange in residential premises”, practically uncontrolled by the population, plays a major role in preserving human health and longevity.

On the premises, the distribution of air flow to ensure the required air exchange will have the following values:
• toilet - 25 m³/h;
• bathroom - 25 m³/h;
• kitchen - 60 - 90 m³/h - depends on cooking stove;
• in rooms with a long stay of people per person - 25 m³/h;
• in rooms with short-term presence of people (conference hall) for one person - 16 m³/h;
• in smoking rooms - 70 m³/h.

Analyzing the residual strength of large-panel multi-storey residential buildings, it can be noted that the defect in the attachment points of wall panels arises from the loss of tightness of the joint, penetration into thin walls and the formation of condensate on embedded parts and connections, which contributes to corrosive wear of the steel products of the assembly and chipping concrete around them that makes interpanel joints weaker. Humidity in the apartments increases, respectively, the corrosive wear of the embedded parts of the panels increases and the frost resistance of the concrete near the joint zone reduces.

The main reasons for the unsatisfactory condition of these buildings are:
• almost universal end of the safe period of 25-30 years of their operation, and capital repairs in the regulatory terms that were not performed;
• insufficient quality of materials and structures used in construction in the 60s;
• low quality of work on the manufacture and installation of the main supporting structural elements of residential buildings built in the 60-90s.

The analysis of literary sources and the author’s experience in technical surveys of the objects under consideration allows us to make the following conclusions:

1. The changed operational conditions of residential buildings, as well as the massive changes in the life and lifestyle of the average citizen of the country, contribute to increasing the humidity of the indoor air in apartments, which in turn increases the moisture content in external enclosing structures and reduces their heat transfer resistance and requires increased air exchange, which contributes to additional heat losses.

2. Mass use of plastic windows, double-glazed windows; of modern building materials and products based on synthetic materials; of furniture, carpets, interior items from plastics and with the use of synthetic materials; of efficient household appliances and household chemicals require the organization of a reliable and sufficiently powerful ventilation system in the apartments that would perform the necessary air exchange of rooms to ensure acceptable living conditions, according to the requirements of SP 60.13330.2012 Heating, ventilation and air conditioning [3].

3. The strength and stability of multi-storey residential buildings of the 60-90s are currently in critical condition, especially interpanel joints and interfaces, which form the basis of the supporting elements of residential buildings.

4. To ensure the safety of the housing stock, to reduce heat and energy costs to ensure acceptable living conditions in it, it is necessary to carry out a comprehensive reconstruction of residential high-rise buildings of the 60-90s.

5. The complex of measures to restore residential multi-storey buildings should include measures to restore the insulating properties of exterior wall panels, to reduce energy costs, and measures to strengthen the bearing and enclosing structures that have undergone maximum physical wear [4].

3. Experimental part
Two options are offered for thermal modernization of residential building facades:

I variant – scheme of using monolithic claydite insulation using fixed formwork fig.2, 3, 4, 5.
Figure 2. Steel frame for monolithic insulation.

Figure 3. Knot of fastening of tiles of a timbering to a steel frame.
Figure 4. A view of building after repair.

Figure 5. Constructive scheme of monolithic claydite insulation.

The order of organizing monolithic lightweight concrete wall insulation of residential buildings:
1. Preparation of exterior surfaces of the walls of a residential building, i.e. cleaning wall surfaces, cutting seams between wall panels or blocks, removing degraded plaster areas, stucco decorations, etc.
2. Installation of a steel bearing frame of vertical and horizontal elements and fastening to the outer wall using spacer anchors.
3. Installation and fastening of permanent formwork from polystyrene foam plates.
4. Filling and compaction of the light-weight concrete mixture into prepared formwork.
5. Installation of metal reinforcing mesh on the outer surface of the formwork of polystyrene foam plates for decorative and weatherproof plaster.
6. Putting decorative weatherproof plaster or putty.
7. Coloring by decorative weatherproof compositions.

**II variant** – scheme of thermal modernization of the exterior walls of a multi-storey residential building with the help of attached loggias.

![Diagram](image)

**Figure 6.** The scheme of thermo-modernization of the outer wall of a monolithic residential building with the help of attached loggias.

![Image](image)

**Figure 7.** Facade of a residential building, insulated by extension of glazed loggias.

The list of works on the attached loggias
1. Organization of bored piles around the perimeter of the building.
2. Concreting of the pile caps under the bearing logs of the loggias.
3. Concreting of the main bearing structures, i.e. walls and ceilings of attached loggias along the perimeter of a residential building.
4. Glazing loggia, fencing.
5. Installation of recuperator installation and air ducts.
6. Finishing work.

A more detailed description of the writing technology of proposed options organization for thermal modernization is presented in the description of two innovative patents of the Republic of Kazakhstan [6, 7].

4. Conclusions
1. There is a large number of proposals how to thermally modernize the facades of residential buildings [5].
2. All these methods have their own application area, characterized by their strengths and weaknesses.
3. Two proposed variants of solutions for the thermal modernization of large-panel residential buildings of 60-90s are the most technological, simple in organization and control the quality of work:
   I variant – scheme of monolithic claydite insulation using fixed formwork;
   II variant – scheme of thermal modernization of the external walls of a multi-storey residential building with the help of attached loggias.
4. Taking into account the continuous glazing and the addition of additional floors, the last proposed option is the most preferable from the point of view of investments, since its implementation completely pays for the reconstruction of the object and allows the investor to get additional profit on the invested capital.

References
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