Technology for repairing and improving energy efficiency of enclosing structures of large-panel buildings of the 1-335 series

A V Petrov\textsuperscript{1}, A G Petunin\textsuperscript{1} and E V Samarkina\textsuperscript{1}

\textsuperscript{1}Irkutsk National Research Technical University, 83 Lermontov str., Irkutsk, 664074, Russia

E-mail: termina@mail.ru

Abstract. The article deals with technological and design solutions for repairs with increasing the thermal properties of wall panels of large-panel buildings of the first series of mass developments. A technology for restoring wall panels using modified structural and heat-insulating concrete is proposed. The technology of repair of gas-concrete panels increases the thermal characteristics of building envelope structures to the level close to the standard, reduces their physical wear. Analysis of repair and restoration works of gas-concrete panels with modified material showed the rationality and financial attractiveness in comparison with the method of shotcrete and subsequent insulation and installation of a ventilated facade.

1. Introduction
Starting from the 60s, there was a mass development of Soviet cities with residential buildings of the 1-335S and 1-335A series (AC, CB) - large-panel buildings with incomplete and full precast concrete frames, respectively.

Buildings of the 335 series, operated for 30-40 years or more without repair and protection measures, have typical defects. These are mainly foci of frost destruction in areas where condensation accumulates, resulting in local defects and damage to the cellular concrete of load-bearing wall panels (zones of window and door openings, mounting and intersectional seams). The destruction of the solution of external panel seams activates the physical aging of materials, and, as a result, the formation of cold bridges, violation of steam and waterproofing with regular moisture saturation of the seam cavity. In this case, along with operational inconveniences and violations of the appearance and facade, irreversible processes of metal corrosion of welded embedded parts occur – and this is one of the issues of ensuring the structural reliability of the building.

To date the standard operating time and technical resource of wall bearing and enclosing structures of large panel buildings of the 1-335 series have been exhausted.

2. Materials and methods
In the Irkutsk region, numerous surveys confirm the presence of defects and damages in the external wall panels made of gas-reinforced concrete, indicating a decrease in the operational reliability of buildings of efficiency. For seismically active areas, the regulatory requirements have been significantly increased, which the buildings under consideration objectively cannot fully comply with.

A very acute problem is the continuous stratification of the north-west orientation load-bearing wall panels, which are subject to intense effects of atmospheric precipitation, with the threat of their sudden
collapse. The technical condition of the enclosing structures is significantly aggravated for houses of the 1-335S series with an incomplete frame, when all the load from the floor structures is transferred to the stratified emergency panels, resulting in a drawdown of the crossbars and floor slabs with a threat to human life.

The reasons for the appearance of damage to load-bearing wall panels, first of all, lie in the properties of the material itself – gas-concrete:

- increased hygroscopicity of cellular concrete, which includes gas-reinforced concrete;
- low protective properties of gas-reinforced concrete in relation to the reinforcement and, as a result, corrosion of the external reinforcement grids, which leads to the stratification of load-bearing wall panels. This is due, primarily, to the significant decline in the alkaline environment of concrete due to carbonation of lime, directed-porous structure of gas-concrete and the presence of sulfur in the ash-the ash wastes CHP production.

The second main reason for the stratification of gas-reinforced concrete load-bearing wall panels is a gross violation of the production technology of concrete products, namely, uncontrolled “immersion” of the outer grid to a depth of 150-200 mm from the outer surface instead of 40 mm, provided by the project. Compliance with the design requirements for the reinforcement of load-bearing wall panels would preserve the structural integrity of the main part of the material with the inevitable corrosion of the reinforcing mesh, without creating an emergency condition of the external panels of the building and the possibility of restoring the texture-protective layer of concrete at minimal cost.

Moscow has adopted a law on housing renovation, which provides for the demolition of more than 4,500 “khrushchevok” and relocation of their residents to new homes. The program is designed for 20 years and about 2 trillion rubles will be allocated from the city budget.

Figure 1. The layout of houses series 1-335 in the city of Irkutsk.

In the Irkutsk region, there are more than 1,800 houses of the 335 series, and the demolition and construction of new housing will require more than 600 billion rubles. Only in Irkutsk, the minimum necessary volumes of repair, modernization and reconstruction of these series are more than 700 thousand square meters of total area. Figure 1 shows the layout of residential buildings of series 1-335 in Irkutsk.
It should be noted that in June 2017, Vladimir Putin explained at a large press conference that the regions of Russia do not have such financial opportunities, so the repair of large-panel buildings of the 1-335 series is the only solution to the problem.

3. Results
A technology for restoring and improving energy-saving characteristics of gas-reinforced concrete wall panels with modified structural and heat-insulating concrete has been developed. This technical solution was tested on the emergency panels at the end of the building (figure 2), located at the address: Angarsk, 10th microdistrict, 36.

![Figure 2. Spontaneous collapse of gas-reinforced concrete wall panels in the north-west orientation in Angarsk.](image)

The technological process of restoring wall panels is divided into several types of work:

1st - fixing of eaves blocks and dismantling of drainpipes.

2nd – collapse of the emergency layer of concrete with the help of an aerial platform. Special attention is paid to safety in the event of a collapse with the site fencing and the calculation of the danger zone.

3rd – preparatory work. These include the development of the site: installation of scaffolding; preparation of the site for the preparation of modified light concrete; organization of sites for the installation of household and storage facilities; organization of temporary water and power supply, as well as manual electrified tools, etc.

4th - reinforcement works. A reinforcing mesh is installed with attachment to wall panels and columns using chemical anchors.

5th - shuttering works. Before installing the formwork in the lower part of the building, an equilateral corner is attached to the anchors for supporting the formwork. As an experiment, we used wood-plywood formwork, which was installed in tiers.

6th – place concrete work. Production of concrete works is carried out in tiers over the entire width of the building's end face with careful compaction with a deep vibrator.

7th – finishing thermal insulation works. The facade is insulated with a finishing heat-insulating paint coating in several layers, which together with light concrete increase the thermal characteristics of the
repaired panels. Figure 5 shows the technological stages of repair and restoration work on the end of the building of the 1-335 series with a full frame.

4. Discussion
Over the past few years, there has been a growing need for emergency repair of large-panel buildings of series 1-335 of various modifications in Russian cities.

In large-panel houses of the 1-335S series, the crossbars are supported directly on the wall panels. One of the main technical defects of such houses is the construction of support units for interfacing runs of inter-floor floors with metal consoles, made up of two channels № 12, embedded in the supporting ribs of wall panels and being the supports of the runs. As a result of physical wear and corrosion of embedded parts, in March 2005, a five-story large-panel building collapsed in the city of Temirtau in the Republic of Kazakhstan, and in 2006, a part of the house collapsed in Arkhangelsk.

To strengthen the support nodes, Omsk specialists developed and patented an anchor device for unloading the support consoles (figure 3).

For this problem, TbilZRIED recommends that the reinforcement of the crossbar support units on the outer two-layer wall panels, without the device of wall columns (figure 4).

![Figure 3](image1.png)

**Figure 3.** Strengthening of support units of houses of the 1-335 series with an incomplete frame in Omsk.

![Figure 4](image2.png)

**Figure 4.** Ways to enhance existing consoles depending on their state.

1 – panel edge; 2 – crossbar; 3 – channel bar №12; 4 – gain console; 5 – armature; 6 – polymer solution; 7 – pit.

Reinforcement of the crossbar support units is performed by gluing pre-made reinforced concrete elements-consoles, with rebar releases anchored by epoxy polymer solution in pits pre-drilled in the
According to the recommendations, consoles can be made separate for each edge of the panel or paired into two mating edges. The use of paired consoles also allows you to increase the spatial rigidity of the frame.

Currently, since 2004, in Irkutsk, two main methods of restoring the external walls of residential buildings of the 335 series (full frame) have been tested in practice:

1. Dismantling of failed wall panels and replacing them with new products in full;
2. Restoration of the load-bearing capacity of wall panels with reinforced shotcrete with subsequent installation of the insulated ventilated facade system.

The new technology for restoring the operational reliability of wall panels using modified lightweight concrete gives significant advantages in terms of labor costs, and economic efficiency, compared with shotcrete, increases by up to 30 percent.

5. Conclusion

Thus, the proposed technology for repairing gas-reinforced concrete wall panels with modified structural and heat-insulating concrete can be implemented on residential buildings of the 1-335 series of various modifications in the Irkutsk region. The use of this technology will not only increase the operational reliability of gas-concrete panels and reduce their physical wear, but will also solve the current problems of wall panel layering with less financial costs, without resorting to replacing wall panels and temporary relocation of residents.
Figure 5. Technological stages of repair and restoration works of the end of the building series 1-335 with a full frame.

a – securing cornice blocks; b – collapse of the emergency layer; c – installation of armature; d – installing formwork; e – production of concrete works; f – general view of the restored end of the building

References
[1] Petrov A V, Peshkov V V and Petunin A G 2015 Large-panel buildings of the 1-335 series with external wall panels made of gas-reinforced concrete: repair, reconstruct or demolish Bulletin of ISTU 11 (106) pp 85-91
[2] Petrov AV and Petunin A G Reconstruction of large-panel buildings of the 1-335S series with an incomplete frame in the Irkutsk region News of universities. Investment. Construction. Realty 2 (3) pp 105-110
[3] Pinus B I and Gagarski V V 2009 Enhancement of seismic resistance of large-panel buildings Proceedings of the International scientific and practical conference, Irkutsk pp 167-173
[4] Dmitriev A N, Zhdanovsky B V, Koloskov V N and Sukhachev V P 1987 Problems of reconstruction and demolition of five-story panel houses in Moscow Industrial and Civil Engineering 4 pp 28-30
[5] Bulgakov S N 2005 Building materials, equipment, technologies of the 21st century, Moscow pp 60-61
[6] Bulgakov S N 1995 The concept of reconstruction of a 5-storey building of the 60s-70s. Industrial and civil construction 6 pp17-19
[7] Bulgakov S N 1999 Reconstruction of residential buildings pp 47-63
[8] Matveev E P 1998 Technology of reconstruction of low-rise residential buildings by the method of superstructure of floors from volume blocks Housing construction pp 10
[9] Mikhailo V R 1986 Repair of structures of large-panel buildings
[10] Recommendations for inspection and assessment of the technical condition of large-panel and stone buildings 1988 p 57
[11] Reconstruction of buildings and structures 1991 p 351