

**ANALYSIS OF FACTORS INFLUENCING THE INTEGRITY OF INSULATED FACADES OF HOUSES AND SEARCH FOR METHODS OF THEIR REPAIR**

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**Abstract.** In modern construction, after the insulation of facades over time, the next stage is necessary – their repair. Repair of insulated facades preserves and increases the operational efficiency of thermal insulation systems of facades, ensures durability and improves the appearance of the building.

Research results indicate the importance of correct installation and maintenance of insulated facades at the initial stages of construction. It was found that at this stage, various defects can occur, which negatively affect their thermal insulation efficiency and overall reliability during operation. Defects in the installation of insulating materials and other factors can reduce the effectiveness of insulation.

The work examines various aspects of the repair, such as replacement of thermal insulation layers, replacement of damaged components and restoration of the appearance of the facade. One of the key tasks is the restoration of the thermal insulation layer, which may be damaged as a result of mechanical or other influences. It is important to inspect in detail, determine the degree of damage and, if necessary, replace insulating materials that may lose their thermal insulation properties in the future.

In addition, the restoration of the outer finish layer is the part of the process of repairing insulated facades to ensure an attractive appearance of the building and to protect the internal structural layers, especially the thermal insulation material, from climatic and other factors. It was established that over time, different materials of the thermal insulation layer have different indicators of destruction. Particular attention should be paid to the selection of system materials that have similar vapor permeability properties. This approach will help ensure the necessary properties of the thermal insulation system and keep the appearance of the building in perfect condition for a long period of operation.

It has been established that after the restoration of isolated facades, it is important to take care of their maintenance. Properly performing regular inspection and maintenance will help detect possible problems in a timely manner and prevent serious damage in the future. Climate and local building standards must also be taken into account when selecting repair materials to ensure optimal facade performance.

In the process of research, it was found that repair methods are chosen, first of all, based on the technical condition of the building and the degree of damage obtained as a result of the survey. This allows you to choose the appropriate repair methods and assess the associated risks. It should be noted that a specialist who carefully examines and determines the state of facade insulation must have certain competencies in the arrangement and repair of facades.

Therefore, the research results emphasize the importance of quality repair and maintenance of insulated facades to ensure their reliability, efficiency and durability.

It was found that in order to ensure the quality and safety of construction objects, it is important to carry out systematic repair and maintenance of insulated facades, which can be damaged due to various influences. This allows you to preserve the building's energy efficiency and maintain its aesthetic appearance over a long period of operation.

**Keywords:** insulated façade, defects, causes, façade repair, restoration.

**Introduction.** In the modern construction industry, the issues of energy efficiency and heat conservation are becoming more and more relevant. One of the key aspects in this context is the repair of insulated facades, which plays an important role in providing comfortable living conditions, reducing heating costs and increasing the service life of buildings.

However, the repair of insulated facades requires not only technical knowledge and skills, but also the right organizational and technological approach. The ability to choose the best solutions at each stage of the renovation process, taking into account the characteristics of the building, the nature of the damage and the available technologies, is critical for achieving a successful outcome.

This paper examines various aspects of the organization and technological process of repair of insulated facades with plaster finishing. We will consider the selection of optimal materials and technologies, methods for diagnosing and assessing the condition of the façade, as well as effective strategies for planning and executing repair work.

**Analysis of the latest research and publications.** Repair of insulated facades is an important component of the construction process, since the preservation of the thermal characteristics of the building and its appearance depends on its quality. There are a number of key aspects to consider when renovating. Firstly, it is the restoration of the existing insulation layer, which can be damaged due to mechanical or natural influences. In addition, it is important to check and, if necessary, replace insulation materials that have lost their properties over time. Also the repair tasks include the restoration of exterior decoration, which provides not only an aesthetic appearance, but also protection of structures from the influence of negative environmental factors. When repairing insulated facades, it is also important to take into account the choice of materials and technologies that will be most effective in the specific operating conditions of the building [1, 2]. For example, in an area with high humidity, it may be necessary to use water-repellent materials to prevent mold and mildew from forming. It is also important to consider using energy-efficient materials that will help reduce energy consumption for space heating [3, 4]. High-quality repairs allow you to maintain the thermal insulation characteristics of the façade, ensuring the comfort and efficiency of the building. After the completion of the renovation work, it is also important to ensure systematic maintenance and support of the façade in order to avoid problems in the future and ensure a long service life of the building [5-8].

**The purpose of the work** is to determine the factors affecting the destruction of facades, the methods of repair, and how to correctly organize and perform the repair of an insulated facade with maximum efficiency.

**Materials and methods.** System analysis and statistical studies were used.

**Main material and results.** It is known that problems or deficiencies in the building structure or the construction process are detected already at the very beginning of the project or in the first stages of construction. This can be the result of improper design, insufficient attention to the quality of materials, or incorrect work. Detecting defects at an early stage allows you to take timely measures to correct them, which protects against further problems and ensures the quality and reliability of the building or structure and their compliance with current regulations requirements, Table 1.

There are many factors that affect insulated facades during operation. Let's consider the main problems that may arise with the façade of the building during operation:

Damage from weather conditions.

1. Wind action: Insulated facades tend to be less consistent with wind action compared to traditional facades due to the presence of thick insulation. However, strong winds can still destroy

or damage the outer layer, especially if the installation has not been done properly or if the materials used are not strong enough (Figure 1).

Table 1 – Occurrence of disorders at the initial stage

№№ p/n	Type of violations	Recommended parameters for the arrangement of facades with insulation
1.	Violation of temperature standards when performing work	The work should be carried out in accordance with the requirements of current regulatory documents and flow charts. For example, insulation only in warm weather, without sudden temperature changes, or use heat shields under such conditions.
2.	Violation of air humidity standards when performing work	Work should take place at constant moisture levels. It is not recommended to work in high humidity or in direct sunlight on the façade [2, 7, 9].
3.	Unprepared façade	The façade should be even, free of dirt and paint, and have good adhesion properties. Irregularities should be leveled with plaster mortar, and surface differences should not exceed the requirements of the standards.
4.	Use of low-quality materials	It will lead to defects during the installation of facades. For example, cracking of the reinforcing layer, damage to the mechanical fastening of the insulation, namely plate dowels, etc.
5.	Non-compliance with coating technology	All technological operations must be performed in a strict sequence in compliance with all technological requirements. The reinforcing waterproof layer is a plaster that is laid on the façade together with the mesh. It protects the insulation from water and ultraviolet radiation and is the basis of high-quality insulation. The insulation should not be left open, because polystyrene foam is destroyed under the influence of ultraviolet radiation, and mineral wool loses its properties with prolonged exposure to moisture [7, 9].
6.	Wrong organizational decisions.	Low productivity and quality of work.

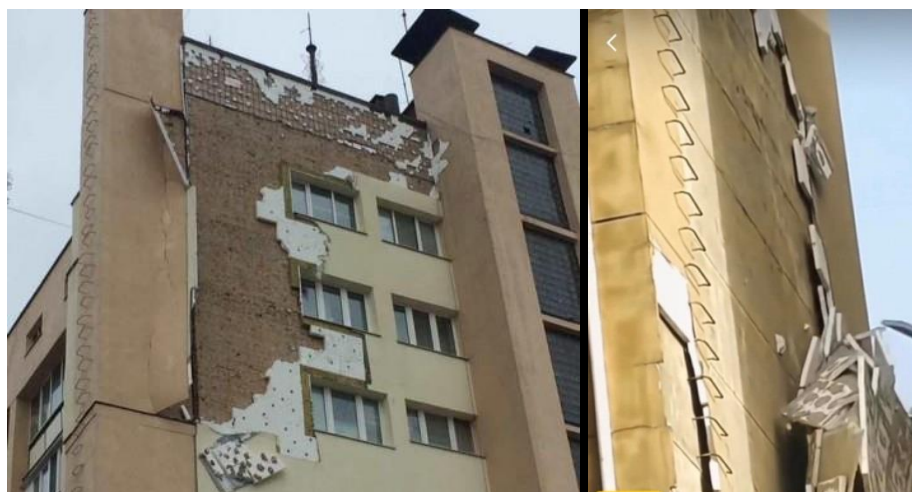


Fig. 1. Destruction of the façade under the influence of wind

2. Exposure to moisture. Insulated facades must have a proper waterproofing layer to avoid moisture penetration into the structure. It is known that moisture that gets inside the insulation can lead to a decrease in its insulation properties and contribute to the formation of mold or rot [10].

3. Thermocyclic changes. Thermocyclic changes can also affect insulated facades. The expansion and contraction of materials can lead to tearing or discoloration of the outer layer. In addition, uneven temperature changes can cause peeling or deformation of the façade coating layers.

4. Improper maintenance:

– Inadequate cleaning: The accumulation of dust, dirt and other contaminants on the surface of the façade can lead to various types of damage. Dust and dirt can alter the appearance of the façade, including yellowing or staining. In addition, some types of dirt may contain harmful substances that can damage the surface of the material or accelerate its wear.

– Inadequate upkeep: A lack of regular maintenance and monitoring can lead to a buildup of problems that can become serious later on. For example, deficiencies in sealing, replacement of worn parts, or repairs not detected and repaired in a timely manner can lead to increased damage and repair costs in the future. Also, inadequate maintenance can include ignoring proper cleaning and protection procedures, which can also lead to accelerated wear and tear of materials and the appearance of defects.

5. Design problems. Incorrect installation: Incorrect fastening or arrangement of the layers of the thermal insulation system can cause serious problems. For example, if there were missing mesh scarves in the reinforcing layer in the corners of the openings, structural deformation, facade panels or other facing materials were not properly fixed to the base of the building, this could lead to their cracking or peeling over time. Also, incorrect installation can cause deformation of materials or violation of their integrity (Figure 2).

6. Ventilation Problems: Inadequate ventilation can lead to condensation inside the walls. If the humidity cannot dissipate properly, it can cause mold, rot, or corrosion to form in the structure of the building. Insulated walls can be the most vulnerable to this, where the insulation layer can trap moisture inside if the ventilation system is not working properly.

7. Chemical factors:

– Interaction with contaminants: Exposure to atmospheric gases, smog, acid rain and other contaminants can lead to depreciation of the façade surface. For example, nitrogen and sulfur oxides found in automotive emissions and industrial emissions can react with the surface of building materials, leading to contamination, yellowing, and loss of aesthetic appearance [11, 12]. In addition, soot, fungi and other biological contaminants can also alter the appearance of the façade and cause damage.

– Exposure to chemicals: Chemical reactions between façade materials and other substances can cause damage to them. For example, contact between acid and metal elements can cause corrosion and destruction of the surface. Also, chemical reactions can occur when any building materials come into contact with aggressive substances, such as solvents or acids, which can lead to their destruction or degradation.

8. Aging of materials.

Fracture due to time: Even if materials have been selected and installed correctly, time can cause them to break down and lose performance. For example, natural factors such as UV radiation, temperature fluctuations, precipitation, etc., can cause materials to damage and lose their strength and elasticity over time. This is especially true for organic materials such as wood or polymeric materials.

9. Destruction of facades as a result of military aggression.

The most common may be damage to the façade after fragments and shrapnel, when the upper plaster and reinforcing layer is completely affected. If the house is insulated, before starting to repair such defects, it is important to check how firmly and reliably the insulation adheres to the surface of the wall. First of all, the plaster and reinforcing layers suffer from the impact of the explosion – they lag behind the surface. In this case, you need to completely dismantle them so that moisture does not get under the system (Figure 3).



Fig. 2. Damaged insulated façade with cracks

To prevent and solve these problems, it is important to carry out regular technical inspection of the façade, take maintenance and repair measures, as well as choose high-quality materials for construction and cladding. Regular examinations allow you to identify problems in the early stages and avoid their further exacerbation. Maintenance, such as cleaning, painting, or repairing local damage, helps keep the façade in good condition and extend its lifespan. Additionally, using high-quality and age-resistant materials can reduce the risk of rapid wear and tear and help ensure the long-term life of the building.



Fig. 3. Damage to the façade from debris and shrapnel

Table 2 is presented below, which contains information about various defects that may occur on the façade of the building. For each defect, a description of its impact on the condition of the façade is provided and a method for solving the problem is proposed. This may include technical inspection, maintenance, repair or replacement of damaged parts, and the application of preventive measures. Such a table will make it easy to identify problems and determine the necessary actions to solve them.

Table 2 – Defects that may occur on the insulated façade [7]

No.№ p/n	Defect	Reason	Solving the problem
1.	Cracks on the decorative layer	This can be caused by improper arrangement of the technological system, for example, there are no expansion joints, temperature changes that lead to expansion or contraction of the material.	For small cracks, you can use special aggregates or sealants for insulation materials. For larger cracks, it may be necessary to replace the affected areas of the material layer, use a reinforced layer or repair kits.
2.	Moisture retention	Incorrect selection of materials for the thermal insulation system. That is, materials with different vapor permeability properties are used. Also, insufficient sealing can contribute to moisture retention inside the structure, which can cause a violation of the properties of thermal insulation materials, and, as a result, peeling, damage to the structure or the formation of mold on the inner surface.	Find the source of moisture formation and eliminate it. If necessary, check and repair any leaks or damage to the decorative layer. The use of waterproofing materials. It may be necessary to replace the affected areas of the material layer or dismantle the decorative or reinforced layers.
3.	Condensation	Poor ventilation or inadequate insulation can lead to condensation forming inside the wall, which can lead to rot or other problems.	Check ventilation systems and make sure they are working properly. If necessary, install additional ventilation to ensure effective removal of moisture from the room. Increase the thickness of the insulation layer.
4.	Paint or plaster smudges	Poor quality paint or plaster, as well as incorrectly selected materials, can cause them to erode or peel off due to atmospheric conditions.	For local repair of damaged paint or plaster, restorative paints or plaster can be used, according to the type of surface. In case of serious damage, it may be necessary to partially or completely replace the paint or plaster.
5.	Appearance of mold or mildew	Moisture that builds up inside an insulated wall due to poor ventilation or leaks can contribute to the formation of mold or mildew, which can be harmful to health.	Remove mold or mildew with special cleaning and disinfecting products. Make sure that the cause of the mold has been eliminated, for example by fixing the leak or improving ventilation.
6.	Damage from mechanical stress	Insulated facades can be more vulnerable to impact or damage compared to traditional facades, as insulation systems are usually less durable.	For local damage, repair kits can be used or paint or plaster damage can be repaired. For more damage, partial or complete replacement of thermal insulation systems or cladding materials may be necessary.



Depending on the types of façade insulation, each of which has its own advantages and disadvantages, destruction from natural conditions may differ. So, for example, when using insulation material:

- mineral wool. The percentage of destruction is about 5-10% during, on average, 20 years of operation, depending on the density of the insulation and the type of protective and decorative materials. This means that, on average, over 20 years of operation, about 5-10% of insulation facades made of mineral wool may need to be repaired or replaced due to various reasons, such as wear, deformation or damage due to weather conditions or improper use [9]. However, With the correct selection of materials for the thermal insulation system, the period of effective operation of facades with plaster finishing is up to 28 years [13].

- polystyrene foam (PPS or EPS). The percentage of destruction is approximately 10-15% during 23 years of operation, depending on the density of the insulation and the type of materials of the protective and decorative layer. It is advisable to use in places with high rainfall. This means that insulated facades made of expanded polystyrene are more resistant to climatic conditions, but they are characterized by less environmental friendliness and fire resistance.

- extruded polystyrene (XPS) (rarely used for thermal insulation of facades). The percentage of destruction is approximately 2-3% over 20 years of operation. This means that insulated facades made of extruded polystyrene can show a similar level of problems as those used with mineral wool over a longer period of time.

These figures are general estimates and can vary depending on various factors such as material quality, installation quality, climatic conditions, and others.

Taking into account the above factors of façade damage, the next step is the choice of repair methods.

Choosing the appropriate repair option in each case has several requirements:

- repairs must be cost-effective;
- aesthetic requirements;
- the degree of various wear mechanisms;
- requirements for the service life of repairs;
- requirements for the reliability of repairs.

Depending on the degree and extent of damage:

- easy repair of the coating;
- patching and repair of the coating;
- removal and application of plaster;
- repair of the entire façade insulation system.

All requirements for choosing a repair method do not have the same meaning. Repair methods are selected primarily on the basis of the technical condition of the structure [14, 15]. The one that best meets the architectural and financial criteria of the project is selected, then selected from among those that meet the technical requirements. Figure 4 shows the principles of choosing a repair method.

Thus, it is established that repair methods are chosen, first of all, based on the technical condition of the building and the degree of damage, which is obtained as a result of the inspection of the condition. This allows you to choose the appropriate repair methods and assess the risks involved. It should be noted that a specialist who carefully examines and determines the condition of façade insulation must have certain competencies in the arrangement and repair of facades.

Thus, the results of the research emphasize the importance of high-quality repair and maintenance of insulated facades to ensure their reliability, efficiency and durability.

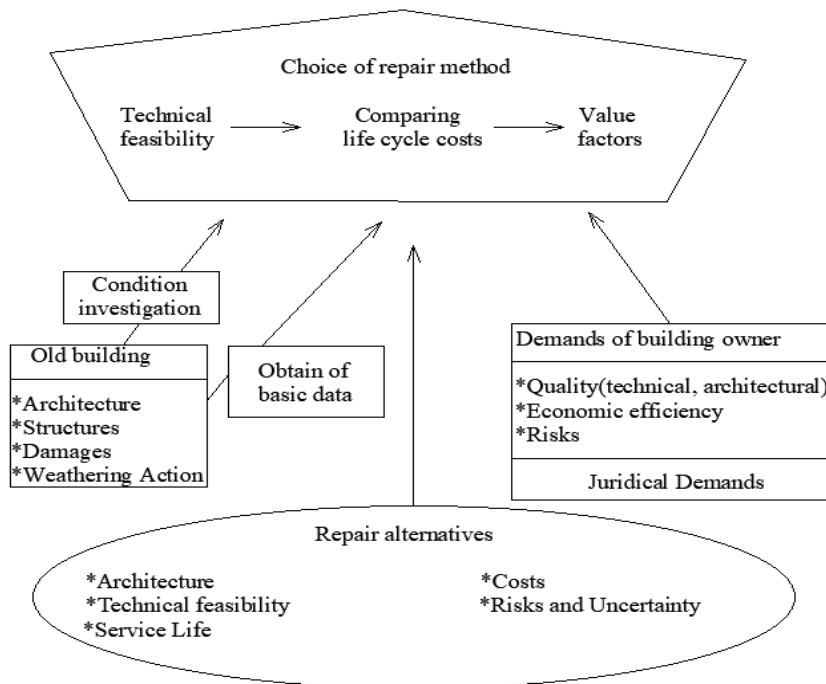


Fig. 4. Various factors influencing the decision on the method of repairing the thermal insulation of the façade

### Conclusions:

1. In modern construction, after the insulation of the facades, the next stage is necessary over time – their repair. Repair of insulated facades preserves and increases the operational efficiency of thermal insulation systems of facades, ensures durability and improves the appearance of the building.
2. Research results indicate the importance of correct installation and maintenance of insulated facades at the initial stages of construction. It was found that various defects may occur at this stage, which negatively affects their thermal insulation efficiency and overall reliability. Defects in the installation of insulating materials and other factors can reduce the effectiveness of insulation.
3. It was found that in order to ensure the quality and safety of construction objects, it is important to carry out systematic repair and maintenance of insulated facades, which can be damaged due to various influences. This allows you to preserve the energy efficiency of the building and maintain its aesthetic appearance over a long period of operation.
4. It was established that over time, different materials of the thermal insulation layer have different indicators of destruction.
5. It has been established that repair methods are chosen, first of all, based on the technical condition of the building and the degree of damage obtained as a result of the survey.

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## АНАЛІЗ ФАКТОРІВ, ЩО ВПЛИВАЮТЬ НА ЦІЛІСНІТЬ УТЕПЛЕНИХ ФАСАДІВ БУДІНКІВ ТА ПОШУК МЕТОДІВ ЇХ РЕМОНТУ

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**Анотація.** У сучасному будівництві після утеплення фасадів з плином часу необхідний наступний етап – їх ремонт. Ремонт утеплених фасадів зберігає та підвищує експлуатаційну ефективність систем теплоізоляції фасадів, забезпечує довговічність та поліпшує зовнішній вигляд будівлі.

Результати досліджень свідчать про важливість коректного улаштування та обслуговування утеплених фасадів на початкових етапах будівництва. Виявлено, що на цьому етапі можуть виникати різноманітні дефекти, які негативно впливають на їхню теплоізоляційну ефективність та загальну надійність при експлуатації. Недоліки у монтажі ізоляційних матеріалів та інші фактори можуть знизити ефективність утеплення.

В роботі досліджено різні сторони ремонту, такі як заміна теплоізоляційних шарів, заміна пошкоджених компонентів та відновлення зовнішнього виду фасаду. Одне з ключових завдань – це відновлення теплоізоляційного шару, який може постраждати в результаті механічних або інших впливів. Важливо детально оглянути, визначити ступінь ушкодження і, за потреби, замінити ізолюючі матеріали, які можуть втратити теплоізоляційні властивості в майбутньому.

Крім того, відновлення зовнішнього фінішного шару є частиною процесу ремонту утеплених фасадів, щоб забезпечити привабливий зовнішній вигляд будівлі та захистити внутрішні конструкційні шари, а особливо теплоізоляційний матеріал від кліматичних та інших факторів. Встановлено, що з плином часу різні матеріали теплоізоляційного шару мають різні показники руйнування. Особливу увагу слід приділити вибору матеріалів системи, що мають аналогічні властивості з паропроникності. Цей підхід допоможе забезпечити необхідні властивості системи теплоізоляції та зберегти зовнішній вигляд будівлі в ідеальному стані протягом тривалого періоду експлуатації.

Встановлено, що після відновлення ізольованих фасадів, важливо дбати про їх догляд і обслуговування. Належне виконання регулярної перевірки та обслуговування допоможе своєчасно виявляти можливі проблеми і запобігати серйозним ушкодженням у майбутньому. Необхідно також враховувати клімат і місцеві будівельні стандарти при виборі матеріалів для ремонту, щоб забезпечити оптимальну експлуатаційну ефективність фасаду.

В процесі дослідження виявлено, що методи ремонту обираються, в першу чергу, виходячи з технічного стану будівлі та ступеню пошкодження, яка отримана в результаті обстеження. Це дозволяє вибрати відповідні методи ремонту та оцінку пов'язаних з цим ризиків. Слід зауважити, що фахівець, який ретельно обстежує і визначає стан фасадного утеплення повинен володіти визначеними компетенціями в улаштуванні та ремонті фасадів.

Отже, результати досліджень підкреслюють важливість якісного ремонту та обслуговування утеплених фасадів для забезпечення їхньої надійності, ефективності та довговічності.

Виявлено, що для забезпечення якості та безпеки будівельних об'єктів важливо проводити систематичний ремонт та обслуговування утеплених фасадів, які можуть бути пошкодженими внаслідок різних впливів. Це дозволяє зберегти енергоефективність будівлі та підтримувати її естетичний вигляд на протязі тривалого часу експлуатації.

**Ключові слова:** утеплений фасад, дефекти, причини, ремонт фасадів, відновлення.

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