Increasing of the Energy Efficiency in Civilian Buildings Applying Fixed Type of Facade Systems

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INCREASING OF THE ENERGY EFFICIENCY IN CIVILIAN BUILDINGS APPLYING FIXED TYPE OF FACADE SYSTEMS *

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Abstract. The analysis of the technical condition of the fixed assets of the housing and communal sector of the country is presented, the main part of which are civil buildings. It is shown that the housing stock does not meet modern requirements of thermal engineering standards, energy saving and energy efficiency of buildings. To create the necessary microclimate of living quarters with a comfortable living environment, most civil buildings built at different times need modernization. To effectively carry out overhaul requires a comprehensive approach to the technology of repair and construction with the use of modern energy-saving technologies and materials. Effective implementation of thermal insulation of enclosing structures should be preceded by a detailed survey of the technical condition of facilities with the issuance of scientifically grounded recommendations based on modern scientific achievements in this field, for the further development of a technical task for the design of these works.

The main component of the housing and communal sector (HCS) of the country are civil buildings that represent the housing stock and social infrastructure facilities. At present, special requirements are required to create a comfortable living environment, meet the requirements of increasing energy efficiency and energy savings, increase operational reliability, and improve architectural expressiveness. Their implementation is a task of national importance and scale in the field of construction and housing and communal services of the country [1]. In addition, it is the largest sector of the Russian economy, which includes more than 26% of its total fixed assets. About 20 million objects of housing stock make up almost 3 billion square meters and consume more than 20% of the country's energy resources. The annual turnover in the housing and communal services sector exceeds 4,1 trillion rubles and is more than 5.7% of Russia's gross domestic product. Nevertheless, this is the most problematic branch of the economy. Depreciation of its fixed assets exceeds 60%, and in some respects it is higher. Among the problems hampering the development of the industry are: non-state system, administrative management, cost management, opacity of tariff formation, lack of public awareness, high percentage of moral and physical deterioration of communal infrastructure, and many others. But all these reasons can be attributed to subjective factors.

For the effective implementation of the tasks facing the industry, it is necessary to solve a set of measures that take into account its objective state. In the last decades of the reform of the housing and communal services, since the 1990s, numerous legal and regulatory acts have been developed in this area, including the "Strategy for the Development of the Housing and Communal Services of the Russian Federation for the Period to 2020" adopted January 26, 2016. The development strategy was supposed to contribute to improving the comfort of living conditions, upgrading and improving the energy efficiency of housing and communal services, the transition to the principles of the use of modern efficient materials and technologies used in the construction and modernization of public infrastructure and housing facilities, ensuring the accessibility of multi-apartment houses) for people with disabilities and other low-mobility groups.

But in connection with the fact that the approaches outlined in the strategy are mostly subjective in nature, the effectiveness of its implementation is far from expected [2]. Domestic experience clearly demonstrates the feasibility of using little-known and not currently used mechanisms and technologies. In

work [3] the questions which are very actual for carrying out of reforms in a housing sphere and municipal (city) economy are opened.

The civil buildings currently under construction are more likely to meet energy efficiency requirements. As for the buildings built at different times, most of them do not meet the modern heat and technical requirements. Bringing them to the standard thermo-technical indicators requires major repairs and reconstruction, and, first of all, built according to the old thermal engineering standards. The desired effectiveness in this process can be achieved only by increasing the repair and construction industry itself, based on the results of a professional survey of the technical condition of civil buildings. To solve this task, an integrated approach to the technology of repair and construction works using modern energy-saving technologies is needed, and different from the traditional, generally accepted methods of organizing repair and construction.

Experience in carrying out major repairs showed that fragmented, unsystematic and local tasks did not solve the global problems of reducing the high energy consumption of buildings [4]. This led only to additional costs for such work, and the aging of the housing stock, its under-repair led to an increase in the amount of old and dilapidated housing and a decrease in the level of comfort.

When carrying out major repairs, in addition to ensuring the required parameters of the internal microclimate and operational reliability, a special role is assigned to improving the energy efficiency and energy saving of the renovated buildings. The main object of this goal is the enclosing structure. Since the publication of Federal Law No. 261-FZ "On Energy Saving and Energy Efficiency Improvement ...", almost all regions of Russia have begun to carry out major repairs of external fences of all types of buildings within the framework of implementing the requirements of this law. At the same time, the main indicators of the effectiveness of repair and construction work were the number of renovated houses and the volume of development of funds. The issues of quality and durability of the facade insulation stood in the background, and there was no scientific justification for such works at all. This was easily explained by the fact that the repair work should be preceded by a professional detailed examination of the technical condition of the facilities with the issuance of scientifically grounded recommendations based on modern scientific advances in the field of thermal insulation of enclosing structures for the further development of a technical design for the design of these works. But the payment for carrying out this kind of work has always remained a big problem.

Nevertheless, the work on efficient facade heat insulation requires a serious scientific approach with the aim of economical and technological efficiency of its choice and design. We must not forget that applied and fundamental scientific research is the direct source of innovative and breakthrough technologies, including in construction.

Enclosing structures that are exposed to the external and internal operating environment, is a complex thermodynamic system that obeys physicochemical laws, processes and phenomena. Therefore, it is possible to effectively manage its thermophysical properties only on a scientific basis. This is especially important when it comes to the use of new building technologies, materials and heat insulation systems. As already noted above, in the previously constructed residential houses, external enclosing structures were subjected to various technological methods to meet their thermal and technical parameters. But they did not completely solve the problems posed by modern thermophysics [5]. In this regard, almost all the enclosing structures require major repairs for their insulation.

For a correct understanding of the need for insulation of the enclosing structures of residential buildings, it is necessary to have a picture of the processes occurring under the influence of various factors both inside the building and outside.

The durability of the enclosing structures, and especially their thermophysical properties, is significantly influenced by climatic conditions: atmospheric precipitation, diurnal and seasonal temperature variations, wind loads, solar radiation, bio-corrosive processes, and processes and phenomena within structures, caused by these conditions. The influence of these factors leads to a decrease in operational reliability, both the enclosing structures and the whole building as a whole [6]. In the course of time, the thermophysical indices deteriorate noticeably.

The outer enclosing structure is the phase-separation surface when cold external and warm internal operating environments interact. At the same time, both on the surfaces of this border and inside it, new processes and phenomena occur that have a significant impact on the quality of thermal insulation, the internal microclimate of the premises, as well as on the operating floor.

Atmospheric precipitation (rain, snow, fog) leads to the moistening of external fences. Getting to the surface of the fence, the water through the open pores through the capillaries penetrates into the thickness of the fence, and can be found there in all three of its aggregate states: liquid, solid and gaseous (vapor).

When the temperature is lowered, a phase transition of water into ice occurs with an increase in volume by a factor of nine. This, in turn, leads to the formation of internal stresses in the material of the fence, causing mechanical damage. As the temperature rises, the reverse phase transition of ice into water occurs. The internal stresses decay, leaving in the body of the structure from the outside the originated network of microcracks from the previous freezing. Then the process repeats, and each new cycle contributes to greater penetration of moisture, and, consequently, to greater destruction. The greater the difference between diurnal and seasonal temperature fluctuations, the stronger and more often these processes occur (the mechanism of frosty destruction). The constant action on the wetted wall of the alternating load leads to its intensive destruction. It should be remembered that the moisture inside the enclosing structure in different quantities is always present, not only from the effects of atmospheric precipitation. It is subdivided into: building moisture, ground, hygroscopic and operational. Construction moisture is caused by the consequences of "wet" construction processes, its amount depends on the heating and ventilation systems. Ground moisture penetrates into the enclosure by capillary suction with poor vapor and waterproofing. Hygroscopic (sorption, vapor) moisture enters the interior of the structure due to the hygroscopicity of its material. A special role in the moistening of external fences is given to the operating moisture, which is often neglected. Nevertheless, water vapor is contained in the exhaled air of a person, a large number of them are formed from domestic and industrial activities, cleaning of premises, operation of water supply and sanitation systems. Excessive pressure causes water vapor to move outside the building. Part of the moisture leaves the room with the help of natural and forced ventilation systems, and some fall into the fences and try to get out. In this case, the steam condenses on cold surfaces and turns into condensed moisture. The place of this phase transition is usually called the dew point. Negative effects of humidification of external walls can be manifested not only from the effect of negative temperatures. Under the influence of sunlight and light, a favorable environment for the emergence and development of mold, rot, fungi and other microorganisms is created on the moistened fencing system inside and on the surface. This reduces the hygienic indices of the indoor microclimate of the premises and leads to negative consequences for the residents. It follows that the outer fences of civil buildings must meet a number of requirements. They should be cheap in erection and operation, strong and durable, fulfill their functional purpose, providing energy efficiency of the building with the required internal microclimate and being architecturally expressive.

To meet these requirements, there are currently various multi-layer facade insulation systems on the construction market. In the new construction there are three types of location of the insulation of the building: internal, directly in the bearing wall, external. When it comes to the insulation of already erected and inhabited houses during their overhaul, there is a question of ways of warming, from which side it is more effective to have a heater. Insulation from the outside is most suitable for residential buildings, as it has a number of advantages: the use of the effect of heat accumulation by the bearing structures of the building; removal of the "dew point" beyond the support structure; The useful volume of the room does not decrease.

In the reconstruction of old buildings, the most easily realized and effective is the external thermal insulation system, which is no less successfully used in new construction [7]. All of them are divided into plaster and ventilated, have their own design features, advantages and disadvantages.

Plastering refers to the systems of insulation of facades of fastened type or - the system of "wet" facades and is divided into light and heavy. The arrangement of facades of this type provides for lowering the cost of heating the building from 40 to 50%, reducing the loss of thermal energy through the enclosing structures and reducing the payment for thermal energy, improving indoor comfort in the premises, reducing emergency situations. Such facades play an important role in their construction on the real estate of the municipal formation, which leads to an improvement in the quality and reliability of heat supply, a reduction in fuel consumption, the release of additional heat capacity, an increase in the life of the housing stock, a reduction in tariffs for thermal energy.

Hinged facades of fastened type can be effectively used in industry, in the construction and improvement of private houses, common house systems, including. apartment buildings, social institutions (schools, hospitals, kindergartens, etc.), administrative and public buildings and structures.

Light plastering facade insulation systems are a multi-layer heat-insulating and decorative design in which the insulation is fixed with the help of adhesive composition and mehanic devices on the outer surface of the fence. Then the warming layer is covered with a protective and decorative layer of plaster, not more than 15 mm thick.

In general, the warming system "light wet method" allows to achieve a high-quality insulation of the building at a relatively low cost with high artistic and decorative expressiveness of the facade. However,

the use of even the most expensive and high-quality materials does not guarantee the high quality of the work performed. Unfortunately, in the market of facade insulation you can meet companies whose "professionalism" can negate all the potentially high characteristics of such systems.

Heavy plastering facade systems consist of consecutively applied layers of insulation and plaster structures, carrying the functions in which the reinforcing mesh fulfills. In this case, the thickness of the plaster layers after the layer of thermal insulation, in contrast to light plastering systems, can reach 50 mm. A distinctive feature of such systems is that in them the insulation is not glued to the external wall, but is fixed by means of special dowels-anchors.

These systems have much longer service lives than light stucco facades. The guaranteed service life of some manufacturers is declared up to 50 years (light systems are guaranteed to serve for about 20 years). This has led to a very large number of their popularity in the Scandinavian countries. In our country they are just beginning to gain their authority.

The thickness of the thermal insulation of the outer wall should not be less than 100 mm. Costs for the thermal insulation of external walls are made up of the cost of materials (thermal insulation, plaster mixes, mesh, dowels, decorative finishing) and the cost of work. As practice shows, the difference in total costs when using thermal insulation thickness of 50 mm and 100 mm will be about 10% and the effectiveness will differ by one and a half times. Increasing the thickness of thermal insulation above 150 mm is not economically profitable. The total cost will grow much faster than the effect of saving heat. So, the optimal thickness of thermal insulation for the insulation of external walls (when using thermal insulation with a coefficient of thermal conductivity $\lambda \leq 0.041$ W / m·S) is 100 ... 150 mm.

Unlike other systems of external thermal protection of a building, in a system of thermal insulation of a "wet" type, the outer material can be applied practically of any kind, i.e. to reconstruct old buildings with preservation of architectural appearance, and in new construction to preserve the architecture of the whole district. The main difference between the "wet" type heat insulation from another popular thermal insulation system with the help of "ventilated facades" is the absence of an air layer.

The main advantages of the external thermal insulation of the building "wet" type: 1) are used in the reconstruction and new construction of any type of buildings; 2) there is practically no restriction on use; 3) ensure compliance with the norms and rules of the Russian Federation in the construction and operation of buildings; 4) the calculation of the thermal insulation system is not laborious, does not require much time (but requires a sufficient amount of experience, since the use of materials with incompatible properties will lead to additional unscheduled repair work); 5) improve the sound insulation of buildings; 6) installation is simple and does not require much time; 7) service life according to the manufacturers' data of 20-25 years; 8) cheaper in comparison with the system of "ventilated facades"; 9) low cost of repairs; 10) almost any materials can be used for facing the building; 11) reduces the heating of the house wall in hot weather, making the conditions in the rooms more comfortable; 12) in comparison with the "ventilated facade" the facade of the "wet" type does not create a draft of air, thus the system will not allow rapid spread of ignition.

At the same time, there are restrictions on the use of external thermal insulation of the building "wet type", namely: 1) the installation of systems can be performed only at an air temperature of more than 5 ° C, in the absence of external weather influences; 2) the plaster layer is sometimes exfoliated and damaged (since it does not have protection from external influence), it is necessary to monitor the building constantly, because the integrity of the thermal insulation layer may be impaired; 3) operation is allowed at an average daily minimum temperature of the coldest five-day period of the year not lower than 55 ºC; 4) in the reconstruction of old buildings, damaged walls are difficult to dry from accumulated moisture and even; 5) the height of the building is not more than 75 m (15 floors).

The thermal insulation of the "wet type" facades is most often used in low-rise buildings up to 15 storeys. It should also take into account the fact that this system of thermal insulation practically does not react to wind currents, because of the low load-carrying capacity on the walls.

In the old housing stock under reconstruction, the insulation of the facades of buildings with painting or coating the outside with plaster is an economical way of finishing the building with thermal insulation and has no alternative to other similar products. The payback period depends on the material and height of the building, the thickness of the heat-insulating layer, the facing material, the manufacturer of the insulation, but do not exceed 5-10 years. the economy of thermal energy reaches 40-60%.

To prevent even the minimum accumulation of moisture between the heater and the wall, and to prevent the insulation from peeling off the wall during the freezing of thawing, it is necessary to correctly choose the thickness of the insulation in order to fully take the dew point to the insulation. This will solve the problem of the fungus in the wall.

Removal of the dew point in the heater, adherence to technology and proper performance of the work will lead to a high-quality warming of the walls, and will help create a comfortable microclimate in the house during the long period of operation of the thermal insulation system.

Due to limitations in the use of a thermal insulation system for high-rise buildings (a building over 15 floors high), it is practically not used, but is suitable for finishing loggias and balconies.

The main point to pay attention to when choosing a "wet" type insulation is the variety of manufacturing companies (there are more than 40 of them in Russia) and design organizations. Also, it should be borne in mind that this event in the reconstruction of the old housing stock is most effective in conjunction with glazing of loggias, balconies, installation of modern windows, temperature controllers and individual heat points, etc. The set of measures can give a huge economic effect, with a payback period of 15-25 years.

Thus, the foregoing allows us to conclude that the real increase in the energy efficiency of civil buildings in the process of thermal insulation of their facades can be achieved only by using scientific approaches to solving these problems. This will make it economically and technologically advantageous to choose the type of thermal insulation depending on the climatic location of the facility, the materials and technology of its device. The main thing in solving this problem is that not thermal engineering processes and phenomena affect the operation of the outer enclosing structure, and an effectively designed design spontaneously controlled these processes.

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