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Organization and Technology of Construction of Objects in a Hot Climate

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Abstract: *The article is devoted to the problems of using modern structures and building materials in a hot and humid climate. The main climatic factors that determine the physical parameters of enclosing materials and structures used in given conditions are considered. Examples of solving the problems of adaptation of modern buildings in foreign practice to environmental conditions are given. The latest technological developments in the field of modern building materials are highlighted.*

Keywords: *materials, climate, temperature, humidity, object, mode, factors, physical parameters, design, structure.*

When building city blocks in difficult natural and climatic conditions, along with urban planning and architectural planning methods for organizing residential structures, one of the key points is the correct selection of enclosing materials and structures. Particular attention must be paid to their physical properties, thermal conductivity, resistivity, optical reflectivity, etc.

It is also necessary to take into account the location of the construction object, because due to climate-forming macro- and micro-scale factors (radiation conditions, wind regime, meso- and microrelief form, vegetation, soil, close proximity to the sea, surrounding buildings, etc.) and their combined effect in different areas of the city, the difference in temperature and humidity can be significant.

Studies of changes in air temperature and humidity, as well as wind conditions, are the initial information when calculating the physical parameters used in hot microclimate conditions of enclosing materials and structures without their deformations and destruction during operation. At the same time, it is necessary to take into account the level of comfort for the people living in these buildings.

One of the factors that determine the physical parameters of enclosing materials and structures is their thermal conductivity. It is known that the denser the material, the more thermally conductive it is, which is unacceptable for external building envelopes in hot or cold climates. In turn, a thick wall (even of dense material) can slow down the heat transfer process. Therefore, in order to reduce the transfer of heat from one side of the wall to the other, the thermal conductivity must be reduced in one of two ways: by increasing the thickness of the wall, or by using materials with lower thermal conductivity and higher resistance.

The first method was used in antiquity by almost all the peoples of the hot regions. They built massive walls out of mud or mud bricks.

In modern urban planning, the second method is more often used - the walls are made up of several layers to provide the desired thermal and aesthetic characteristics (isolation of the base material with a low-density material or an air gap reduces the thermal conductivity of the entire wall).

Scientific studies have determined that in hot regions the thermal conductivity coefficient for an external wall should be approximately 1.1 kcal/h·m 2 ·°C in order to achieve adequate thermal resistance. Experiments have proven that it is a brick wall that is the most acceptable material for achieving thermal comfort, as well as the most common. It has a thermal resistance 13 times greater than the thermal equilibrium of a finished concrete wall.

The invention of reinforced concrete ushered in a new era in which traditional architectural forms and methods, as well as building materials, were soon forgotten. However, along with the ease and speed of construction work, concrete brought many problems in terms of creating comfortable microclimatic conditions. Finished concrete structures in their pure form are unacceptable in conditions of both hot and cold climates, because they have low thermal resistance. In order for the outer concrete wall to have a thermal conductivity of 1.1 kcal/hour m2 °C, it must have a thickness of at least 1.0 m.

In the construction of low-rise buildings, this is possible, although from an economic point of view it is unprofitable. During the construction of multi-storey buildings, such masses of buildings will carry an additional load on the ground, which is unacceptable in seismically active areas, and also uneconomical. It follows from this that under these conditions reinforced concrete without insulating sheathing or interlayer is not suitable for the construction of residential buildings and structures as external enclosing structures of multi-storey buildings.

However, today, in a hot microclimate, mostly multi-storey buildings (external walls) are built of concrete, and without insulation. When preparing a concrete mix for construction purposes, it is also very often violated technological processes, which leads to a decrease in the strength of concrete, a deterioration in the pore structure, a decrease in durability and peeling of the outer layers of the concrete structure.

In low-rise construction, the main local building material is limestone. However, 40 cm walls are not able to effectively withstand both summer overheating and winter cold. That is why the width of the outer walls in old buildings in the hot microclimate zone reached 0.8–1 m. Today, in order to reduce the thermal conductivity of the outer walls, it is necessary to lay an insulator (foam, air gap, etc.) between two layers of masonry. During the construction of residential and public buildings, all more often new technologies and building materials are used. At the same time, the necessary studies are not carried out to determine the impact of these know-hows on the state of the environment and the well-being of people. There are also no tests of new materials for endurance in these climatic conditions. For example, in a hot microclimate, enclosing structures operate in a rather hard mode, being influenced by significant temperature changes. Therefore, in order to avoid deformation and destruction (as a result of changing geometric dimensions due to temperature fluctuations) it is very important that the materials combined in a common design have close coefficients of thermal expansion.

With intensive development of residential areas in a hot microclimate, multi-storey buildings practically do not use heat-moisture and vapor barrier materials for external walls, which leads to high energy consumption of the building and the formation of an unhealthy microclimate in the room. In this case, it is desirable to use composite materials with insulation in layers or to apply insulation from the inside of the wall. This will increase the costs during construction, but during operation they will pay off very soon.

In regions with a hot, humid climate, a lot of money is spent every year to eliminate various kinds of problems caused by the negative effects of moisture. The moisture contained in the air inside the building penetrates the wall structure and cools down to a temperature below the point dew, condenses. The amount of moisture generated is greater, the higher the difference between the external and internal air temperatures, therefore, in winter, moisture accumulates quite intensively in the material of the building envelope and causes the occurrence and spread of fungi, mold, rotting of wooden structures, and a decrease in thermal resistance of the building envelope.

Proper design and construction of the outer walls of residential buildings reduces the risk and makes them more resistant to moisture, especially in areas with the highest humidity - these are, above all, areas located near lakes, rivers, sea. In this case, strategies Condensation controls include limiting air leakage, using adequate types of thermal insulation, reducing cold spots, and minimizing the spread of water vapor.

The color of the protected surface is of great importance when protecting against high temperatures. The method of coating external enclosing structures (walls, roofs) with light-colored paint to protect against summer overheating has been known in the East since ancient times. This design, reflecting a significant part of the solar energy back into the outer space, prevented the overheating of the premises, improving the microclimate inside the house. However, reflecting heat back into urban space (streets, courtyards, etc.),

This coating results in an increase air temperature (law of conservation of energy) environment. At present, cities with a hot microclimate are intensively and densely built up with multi-storey buildings, and the heat reflected from the buildings, getting into cramped courtyards, creates a feeling of stuffiness here on windless summer days. The situation is aggravated by the lack of green spaces.

To prevent such a situation, it is necessary to use layered (with an insulating layer) panels and materials in external structures, to actively use landscaping both in the decoration of buildings (balconies, roofs and terraces), and in the planning of courtyards, as well as urban areas. The use of fountains artificial reservoirs in the urban structure also contributes to the cooling of adjacent territories.

In recent decades, mankind has been struggling to improve the efficiency of window and facade glazing. It is a well-known fact that it is these enclosing structures that are, perhaps, the “weakest” point of any residential building. It is through windows and showcases that the maximum heat leakage occurs (up to 60% of the total heat loss) and the penetration of noise and harmful components of the sunlight spectrum.

Modern architecture uses a large range of double-glazed windows (with sound and heat insulation, etc.) and sun protection systems. To improve the thermal insulation properties of double-glazed windows pumped with inert gases. Most often for for these purposes, argon is used. Recently, the "thermal mirror" ("Heat Mirror") technology developed by the American by SouthWall Technologies in the 1980s. In 1980 Southwall Technologies Inc. proposed to use the new double-glazed window in the window industry. STZ became the very first type of glazing with a translucent low-emission coating, and to this day it has no equal in use for any type of buildings and structures. The principle of this novelty is that a transparent membrane with a low-e coating is stretched between ordinary glasses in a glass chamber, which can be applied on one side or on both sides, and forms a two-chamber glass, equal in weight single chamber block.

The use of combined double-glazed windows with the simultaneous use of both a “thermal mirror” and selective glasses makes it possible to achieve a thermal conductivity coefficient of 0.5 m2 °C / W.

Several types of membranes designed for various climatic conditions, allow choose a "mirror" that filters exactly those parts of the solar spectrum that are undesirable for the microclimate of the premises in each specific area. It is possible to choose double-glazed windows for facades of various exposures.

The London-based specialists have gone even further in this area, having developed a new type of glass coated with vanadium dioxide with additives, in particular, tungsten. This coating exhibits dual properties - it behaves like a metal (it reflects infrared radiation well), and then behaves like a semiconductor (transmits thermal radiation). At the same time, while it is cold, the glass remains normal, and as the temperature rises, it reduces the heating of the room by 50%.

Today, glass is the basis for a radical renewal of architectural form, regardless of climatic barriers. The use of glazed surfaces as the outer shell of a building is associated with the spread of energy-saving approaches. Creating a "living" building body that responds to change the degree of its illumination, is increasingly used in public and residential buildings. No less effective is the use of the second, glass, body of the building as a structural element with an energy-saving function.

For example, Jean Nouvel's Torre Agbar tower in Barcelona attracts not only with its unusual shape, but also with its multi-layered shell, resembling the scales of a fantastic fish (Fig. 1). The first layer is a dense concrete shell, lined with colored metal sheets, the second layer is a system of translucent glass blinds, placed at arm's length and responsive to air temperature sensors. Such double façade systems provide natural ventilation of the interior and save space for air ducts and air conditioners. In winter, the facade layer reduces the heat loss of the building.

Fig. 2 Nouvel's Torre Agbar tower in Barcelona

The main material of a double facade, as a rule, is glass, which provides the aesthetic design of the building and performs enclosing functions. In the Düsseldorf City Gate building, the space between the outer and inner parts of the double facade is 1.4 m or 0.9 m is used as passable on all over the balcony. The outer part of the facade serves to protect against external climatic impacts (it also has holes for the supply and removal of air), as well as for ventilation of the intermediate space and natural ventilation of the premises. Adjustable solar shading devices are placed in the intermediate space of the façade. The reduced heat transfer coefficient of a double façade is 1.1 W / (m2 °C).

The principle of operation of the "thermal mirror" can be expressed as follows: "thermal mirror" reflects warmth to its source: in summer, to prevent the penetration of heat into the room, it is reflected outside, and in winter, when it is necessary to retain heat as much as possible, it is reflected into the room. The unique design combines the positive characteristics of double glazing and low-e glass to achieve the highest thermal resistance of windows, close in value to the thermal resistance of walls. The proposed solution is based on the consideration of all the features of the transfer of thermal energy through transparent enclosing structures, which are performed in three main ways: thermal conductivity, convection and thermal radiation.

The desire to reduce the transfer of heat in windows by radiation was expressed in the wide distribution in the world of low-emission, so-called "lower" coatings.

But in the publications of recent years, they are increasingly mentioned as window structures in which the Thermal Mirror TM double-glazed window is used, made using Southwall Technologies technology. And this is no coincidence. The voltage of one or two films with a low level of radiation in the interstitial space solves the problem of bulky window structures with three- and four-layer glazing and, in combination with argon or krypton, increases the energy efficiency of windows so that they begin to perform not only the function of a barrier, but also the function of heating.

True strategic considerations, unprecedented flexibility in "customizing" a building based on orientation, an aesthetically intelligent glazing selection methodology, and a strong R&D base have enabled Southwall Technologies to quickly achieve success in the US market.

Double-layer sectional glass of rooms in Swiss RE building (architect N. Foster), owned by insurance company, allow the air to warm up between the layers and cool down as the sections open. The special matte gray glass coating blocks out 86% of the sunlight, preventing excessive temperature rises inside the premises.

At the same time, the aerodynamic shape of the building increases the access of natural light and air, which significantly reduces energy costs.

In hot, humid climatic conditions, it is necessary to be extremely careful in the choice of building materials and structures. Modern building materials make it possible to solve the most complex structural problems, simplify the installation process and speed up the construction time of facilities. They are also indirect reason for the depersonalization of architecture, the creation similar forms in different regions of the Earth, and insufficient consideration of their physical properties in specific climatic conditions leads to the creation of uncomfortable living conditions for the population in such buildings.

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