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The Use of Sun-Shielding Structures in Large-Scale Light-Transparent Facades for Passive Compensation of Heat Loss to Maintain a Comfortable Room Microclimate

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Abstract: Despite the widespread use of translucent facades of large areas in the architecture of civil buildings, a large number of technical issues related to improving the strength and heat-shielding characteristics of the main materials for the manufacture of facade structures remain unresolved. This article discusses the main options for technical measures to ensure the required heat-shielding characteristics of translucent building envelopes, which directly affect the climate comfort in the premises of civil buildings with large glazing areas. The results of this study make it possible to streamline theoretical and technical information on ways to passively compensate for the influence of large glazing areas on the climatic characteristics of the air environment in civil buildings.

Keywords: translucent facades, thermal characteristics of glazed facades, climatic characteristics of indoor air, insolation, sun protection, overheating of premises.

Introduction.

Since the appearance of the first skyscraper with a fully glazed facade, the use of translucent facades is growing in civil construction exponentially. The possibility of free shaping and modern development of technologies stimulates an architectural thought of the whole world to create unique “glass” buildings with a unique shape. However, glass as a building material has a number of limitations, mainly concerning strength and heat technical characteristics. In this regard, the question of maintenance of a comfortable microclimate of premises in civil buildings with large areas of translucent facades is relevant. In this article questions of application of sun-protection designs are considered, conclusions are drawn on their efficiency.

The main advantages and disadvantages of translucent facades.

Let’s list the main unique positive aspects which are connected with application in construction of translucent facades [7]: – the “facilitated” appearance of buildings; – increase in useful area of premises; – long service life; – feeling of spaciousness and ease in the premises, implementation of the concept “open space”; – freedom of shaping for creation of unique architectural objects.

The main disadvantages of translucent facades [7]: – heat loss of premises in cold season through the glazed surfaces; – overheating of the premises under sunlight; – increasing energy consumption to maintain a comfortable climatic characteristics of the air space; – reducing the illumination of premises associated with the use of low-emission glass coated, frosted and painted; – the psychological discomfort associated with a decrease in the privacy of premises.

The main problems and limitations connected with use of glass for filling of translucent facades.

The main limitations of glass as a building material for translucent facades that have not been resolved to date are the following [10]: – limited size – 3.21 m x 6.00 m; – significant weight – 1 sq.m of glass with a thickness of 1 mm weighs 2.5 kg; – the fragility of glass and impossibility of bending; – low thermal characteristics compared to traditional wall materials. In addition, during operation there are additional negative factors: – destruction of double-glazed windows due to the ” thermal shock” arising at uneven heating of structures; – destruction of double-glazed windows due to the pressure drop in the inter-glass space and atmospheric; – gradual increase in air permeability of windows in connection with wear; – condensation in the places of conjugation of double-glazed windows with a window profile, as well as on slopes of window openings; – increase in relative humidity and air temperature owing to insufficient air exchange in premises.

Application of sun protection devices to control and maintain the climatic characteristics of the indoor air.

The company “Somfy International” conducted a study of employee satisfaction with the quality of lighting in the premises. The results showed that in administrative buildings 86 % of respondents believe that improving the quality of illumination will reduce vision problems during normal office work and 75% would like to independently adjust the level of illumination. It was also found that the need for lighting varies significantly with age and for older people the required intensity of lighting is 40 % higher than the needs of young people [5]. Most of the heat loss in buildings occurs through glazed surfaces and is about 46%, through walls – 30%, through the floor and roof – 10-15% [9]. Experience in the construction of civil buildings with large areas of translucent structures showed that the most expensive part of the operation is the leveling of overheating of the air in the summer, as the cost of cold production is four times higher than the cost of heat production. One of the solutions to this problem is the use of sun protection devices. The main types are discussed in more detail.

In accordance with GOST 33125-2014 [1] sun protection devices are divided into the following indicators: 1) at the place of installation and position relative to the translucent structure: – external; – inter-glass; – inter-glass with ventilation of inter-glass space for installation in double facades; – internal; – a combination of some of the listed places of installation; 2) according to the type of sun protection device and design of shading elements: – solid shading elements (visors, balcony plates, vertical pylons, sun covers; – using a number of parallel slats; 3) according to the control method: – stationary unregulated (passive), including sun and multifunctional glasses, as well as covered with sun films (geometric parameters do not change throughout the life); – adjustable (geometric parameters can change); 4) according to the method of regulation: – actively adjustable (controlled without automated algorithms); – cyclically adjustable (according to the daily or annual cycle); – adaptively adjustable (depending on environmental conditions); – passive-adaptive (due to changes in the aggregate state under environmental conditions); – active-adaptive (depending on the data of meteorological sensors); – several types of control at the same time; 5) orientation of shading elements: – horizontal; – vertical; – General position; – combined; 6) the material of manufacture of shading elements: – metal; – plastic; – fabric; – wood; – decorative concrete; – glass; – composite materials with low values of heat capacity; – special sunscreen and multifunctional glass and film; 7) the level of sun protection: – very high 0-0,2; – high 0,21-0,4; – average 0,41-0,6; – low 0,61-0,8; very low 0,81-1,0.

In accordance with SP 50.13330.2012 [2] the transmittance of solar radiation of the sun protection device should be no more than: – 0.2 – for residential and public buildings; – 0,4 – for industrial buildings. According to SP 52.13330 [3], sun protection devices must provide visual comfort in the premises, for this it is necessary to provide for the use of devices with a rational light transmission

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coefficient, as well as provide: – visual contact of premises with the environment; – exclusion of direct sunlight in the field of view of workers; – ensuring maximum use of natural light in buildings; – minimizing color distortion. According to SP 370.1325800.2017 [4] should be envisaged rational location of shading devices relative to the translucent constructions: – with inside side 1 climate zone; – between glass panes and the inner in the 2nd climatic zone; – the outer South-Western and Western facades in climate zone 3; – exterior, North facade 4 climate zone; – outside in 5 climatic zone. The most effective constructive arrangement of shading elements relative to the cardinal directions: – horizontal (S); – vertical (N, N-E, N-W); – combined (S-W, S-E); – General position (S-W, W, S-E); – casings (universal).

Experience in the construction and operation of buildings with glazed facades and additional shading devices showed the possibility of solving several tasks simultaneously: – to provide the possibility of regulating the flow of solar heat into the premises; – reducing the voltage of the outer glass from the effects of high temperatures; – giving additional architectural expressiveness to the building [6]. In addition, modern systems of specialized lamellas with solar modules integrated into them can significantly save energy costs during the operation of the building.

Conclusion.

It should be noted that the use of active-adaptive systems for regulating the system of shading sun-protection devices is the most expensive and leads to an increase in the initial investment in the construction of buildings. In this case, it requires the creation of complex automated control systems and monitoring the climatic characteristics of energy-efficient buildings based on processing large data arrays (BigData) and using artificial intelligence (AI), which has become possible due to the exponential technological leap of the last 20 years.

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