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Research Article

THE STUDY OF LIGHT CLIMATE FACTORS, TAKING INTO ACCOUNT THE TASKS OF DESIGNING NATURAL LIGHTING, BASED ON NATURAL CLOUDINESS CONDITIONS

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ABSTRACT

This research paper analyses the factors of the light climate, taking into account the tasks of designing natural lighting, based on the natural conditions of cloudiness.

KEYWORDS

Climate factors natural lighting, natural cloudiness conditions.

INTRODUCTION

In lighting engineering, the design of natural lighting is carried out on the basis of the developed calculation methods, which are also used to justify the need to use certain types, shapes and sizes of light apertures in construction, and the compliance of existing natural lighting systems in rooms with the requirements of natural light standards. Moreover, these methods are constantly being improved, modernized, and the aspect of the problems they cover is expanding. In turn, the basis of these calculations are the coefficients and values of the parameters determined by the factors influencing the formation of the light climate of the area. The size of the light openings, the amount of illumination in the premises, as well as the amount of

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heat gain and heat loss through the light openings depend on the correctness and accuracy of taking into account these factors [1-3].

All studies of natural illumination, its dependence on the factors of the light climate, namely the coordinates of the sun, the transparency of the atmosphere, cloudiness and the albedo of the underlying surface, followed the path of accumulating experimental data with their subsequent statistical processing. The change in the above factors during the day and seasons of the year is so uncertain that we can only consider the probabilistic course of variation in natural illumination.

The calculation methods used in lighting engineering, as in other sciences, are based on a mathematical apparatus, which requires, as far as possible, a clearer definition of the nature of the mutual influence of light climate factors on each other, as well as on the amount of natural illumination.

With the uncertain nature of the change in natural illumination over time, it is possible to establish the functional dependencies of the above mutual influences only by averaging and statistically processing the results of long-term observations of the conditions of natural illumination conducted by scientists, both in Uzbekistan and abroad, as well as on the basis of their recommendations for taking into account the influence light climate factors on the amount of natural light [4-6].

An additional complication in this matter is the fact that for different areas, regions, these dependencies differ significantly from each other, and in many cases are of the opposite nature, such as, for example, the uneven distribution of the brightness of the sky along the meridian for the northern and southern regions of our country. The variety of dependences of the mutual influences of light climate factors, as well as the dependences of the influences exerted by them on the amount of natural illumination, are due to the peculiarities of the light climate of a particular region.

METHODS

The light climate of Uzbekistan was studied by N.N. Kalitin, I.N. Yaroslavtsev, E.A. Lopukhin, I.S. Sukhanov, Kh.N. Nuretdinov and others.

Regular study of the light climate in our republic began relatively recently. So Kalitin N.N. On the basis of long-term observational data, the studies revealed patterns of changes in scattered and total illumination depending on the height of the sun above the horizon, the number and shape of clouds, as well as the presence or absence of snow cover.

Later V.V. Sharonov constructed tables for determining daylight illumination for various sun heights and various cloudiness with snow cover.

For the conditions of Tashkent, the above dependencies were determined by E.A. Lopukhin, who studied the influence of individual factors, such as: the height of the sun, snow cover, the amount and type of cloudiness on natural lighting conditions, analyzing the results, obtained empirical dependencies, on the basis of which they created an approximate picture of the light climate for a certain area.

These differences in the conditions of the light climate of the regions necessitated the light-climatic zoning of the territory of our country. So the work says that Gusev N. and Baburin K.E. it was suggested that the illumination is directly proportional to the height of the sun, and light-climatic zoning should be carried out on the basis of the principle of comparing the light energy entering the room per year in different climatic

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regions. Later, on the basis of this, when using the light equivalent, N. M. Gusev and N. P. Nikolskaya compiled a map of the light-climatic zoning of the territory, and also determined the values of the light-climatic coefficients to the normalized KEO values. The experience of using the obtained coefficients in the design of natural illumination, for example, for the southern regions, revealed the unsatisfactory results obtained in this case, the reason for which, in addition to the errors of the calculation method itself, is insufficiently complete and accurate consideration of the characteristics of the light climate and natural cloudiness conditions for these regions [2-3].

Basically, all the results of these works are presented in the form of illumination values, hourly average per day or monthly average, as well as annual and seasonal sums for all periods of observation, regardless of meteorological conditions at the time of observation. The data presented by the authors reflect the influence on the magnitude of illumination of horizontal, vertical and inclined surfaces of various orientations, all physiographic and meteorological factors of those geographical regions where observations were made, i.e. height of the sun, cloudiness, transparency of the atmosphere, the duration of sunshine and the properties of the underlying cover.

The total illumination E_Q after the analysis of its dependence on the factors of the light climate can be considered as the sum of the following components:- direct illumination Es created by the rays of the sun;

- scattered from the vault of heaven E_D;
- reflected from the underlying surface E_3

$$E_Q = E_s + E_D + E_3 \quad \dots (1)$$

So, for example, when the sky is covered with continuous clouds, it is simplified as follows: $E_Q = E_D + E_3$

т.к. $Es=0$ (2)

With a cloudless sky, the total illumination of the surface by the light of the sun and the sky for the simple case of a horizontal surface located openly is represented by the dependence:

$$E_Q = \iint L \cos\theta d\omega + E_{S\perp} \sinh_{\odot} \quad (3)$$

wherein $E_D = \iint L\cos\theta d\omega$ calculated according to the law of distribution of brightness over the sky: $E_S = E_{S\perp}\sinh_{\odot}$

B formulas:
L – brightness of a portion of the sky, at a solid angle;
θ – zenith distance of the axis of this solid angle;
$E_{S\perp}$ – illumination of an area perpendicular to the rays of the sun
$h_{\odot}$ - the height of the sun above the horizon.

The total illumination of a vertical surface can be determined as follows:

$$E_{Q\perp} = \beta E_D + E_{Sb} \quad (4)$$

where β – vertical illumination coefficient;
E_{Sb} – illuminance of a vertical surface, created by direct rays of the sun.
E_{Sb} can be found from the expression:

$$E_{Sb} = E_{S\perp}\cos h_{\odot}\cos(\varphi_{\odot} - \varphi_n) \quad (5)$$

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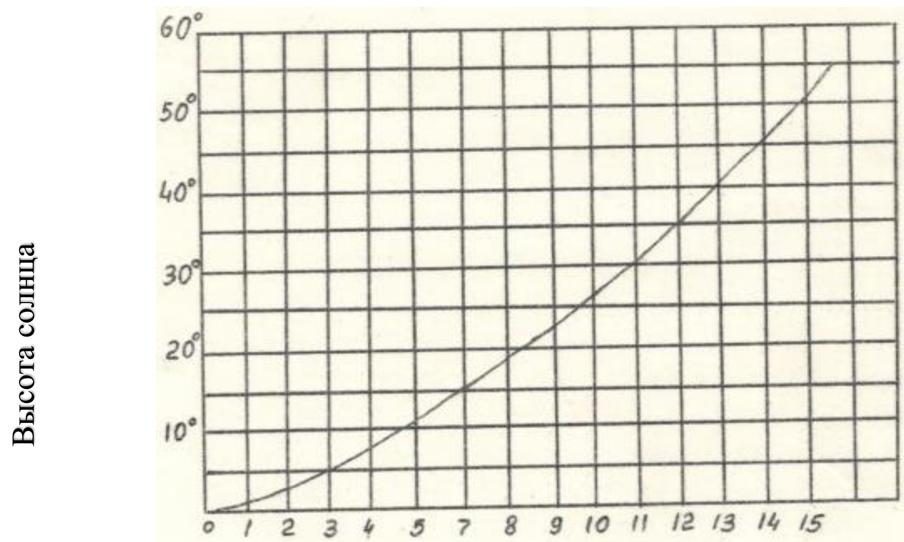
where $\varphi_{\odot}$ and φ_n are the azimuths of the sun and projections with norms to the vertical surface on the horizontal plane, counted from the meridian plane.

Because Since the situations covered by such dependencies are very limited, the most appropriate for establishing the characteristics of the light climate of the area is the analysis of the accumulated experimental data.

In general, the picture of the influence of light climate factors on natural illumination is as follows. As the height of the sun increases, the amount of natural light increases. With a cloudless sky, there is a gradual increase in illumination by sunset, and somewhere up to a height of 200 this increase is more intense, above 20 ° this dependence is observed to be almost linear (Fig. 1)



Illumination in thousand lux

Fig.1. The dependence of illumination on the height of the sun. The sky is cloudless

For a sun height less than 100, the illumination of a horizontal surface by diffused light is greater than the illumination by direct rays of the sun, but as the height of the sun increases, the solar illumination increases and at high altitudes of the sun it significantly exceeds the diffused one.

The appearance of clouds disrupts the course of illumination observed in a cloudless sky. In general, the presence of clouds increases the illumination, but for different heights of the sun and different forms of clouds in different ways. Due to the high mobility of clouds, the constant change in their shape and quantity, location in the sky and, in particular, the relative solar disk, the amount of illumination is constantly changing.

Table 1 below can serve as an example of the dependence of illumination on the presence of forms and amount of clouds at sun heights of 200 and 500 and cloudiness of 5 and 10 points.

Table 1. Illumination of the earth's surface by scattered light of the atmosphere for various types of clouds (thousand lux)

Illumination in a cloudless sky	5 points		10 points	
	illumination	Percentage increased.	illumination	Percentage increased.
At the height of the sun 20^0				
7,3	8,1	11	10	37
7,3	9,6	32	14,2	95
7,3	10,4	42	15,3	110
7,3	10,9	49	11,4	56
7,3	10,4	42	7,7	5
7,3	11,3	55	10	37
At the height of the sun 50^0				
13,6	16,8	24	26,3	101
13,6	21,3	57	32	135
13,6	27,6	103	33,6	147
13,6	22,5	65	34,5	154
13,6	24,3	79	23,6	74
13,6	22,5	65	24	76

It can be seen from the table that in the presence of cloudiness, the illumination increases compared to the values for a cloudless sky, regardless of the type of clouds, and a higher percentage of the increase in illumination is observed at lower sun altitudes. For high and thin cloud forms, the percentage increase is especially high. With continuous and low cloudiness at low altitudes of the sun, the illumination decreases in comparison with the conditions of a cloudless sky. At high solar altitudes, a decrease in illumination is observed with dense cloud masses, with thunderclouds and various forms of rain clouds.

On average, the picture of the dependence of illumination on the amount of cloudiness is as follows. Starting from 0 to 5-6 points, an intensive increase in illumination is observed due to an increase in diffuse illumination, with a further increase in cloudiness to 10 points, the illumination decreases due to an increase in the absorption of light when it passes through the thickness of the clouds.

RESULTS

As a result of many years of research, the dependence of the course of natural illumination on the transparency of the atmosphere was also revealed. With a decrease in the transparency of the atmosphere, the illumination increases significantly. The increase in illumination is due to an increase in the proportion of diffuse illumination as a result of the scattering of solar radiation on particles of moisture, aerosol, dust, etc. suspended in the air.

Moreover, it should also be noted that at the same heights of the sun and the transparency coefficient, diffuse illumination can take on values scattered in a

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certain range of values, and this variability is due to the difference in the optical thickness over the observation point, which affects the nature of light scattering and can change the amount of scattered illumination by 20-40%.

The considered dependence of the increase in scattered illumination with a decrease in the transparency of the atmosphere is limited by a certain limit of the decrease in the transparency coefficient. With a further significant decrease in the value of this coefficient, the nature of the dependence of ED on τ changes. With a significant decrease in the transparency of the atmosphere, dust or smoke, the illumination is significantly reduced due to increased absorption of light on particles suspended in the air. Based on the results obtained by E.P. Barashkova, it can be concluded that the amount of scattered illumination at a constant turbidity factor decreases with increasing absorption.

As noted above, the reflection coefficient of the underlying surface has a significant impact on the change in the amount of natural light.

Light reflected from the surface of the earth can significantly increase illumination. Changing the albedo from 0.2 to 0.8 at a sun height of 30° increases ambient illumination by approximately 50%. The most significant increase in illumination is observed in the presence of snow cover. The percentage increase in the illumination of a cloudless sky with snow cover ranges from 10% (at high altitudes of the sun above the horizon) to 220% (at hʘ=oo) (Table 2)

Table 2. Illumination for a cloudless sky without snow and with snow for different sun heights (in thousand lux)

Sun height	0^0	10^0	20^0	30^0	40^0	50^0
Without snow	0,5	4,6	7,3	9,5	11,6	14,5
With snow	1,6	5,8	8,5	10,8	12,9	14,9
Percentage increased	220	26	17	14	10	10

Zavodchikova V.G. and Kondratiev K.Ya. it was found that changing the albedo from 0.86 (snow falling two days before observations) to 0.89 (snow falling one day before observations) increases diffuse illumination by 30%.

CONCLUSION

An important issue in calculating the natural illumination of designed buildings is the study of the factors that determine the light climate. But here the issue is much more complicated by the fact that the conditions of the light climate for different regions are very different from each other, and this, in turn, changes the conditions of natural lighting. Without accurate consideration of the features of the light climate of the construction area, it is impossible to achieve satisfactory results of calculating the normalization of natural light for buildings designed and built in this area.

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The experience of designing natural illumination of building premises, in particular workshops of industrial enterprises, has shown that with insufficient consideration of all the features of the light climate in the premises, there is significant discomfort in lighting, an incorrectly calculated area of light openings causes a significant increase in the load on ventilation and air conditioning systems, as well as the heating system.

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