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Study of the residential structure's development planning influence on the insolation regime and natural illumination of the territory

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Abstract. The problem of residential buildings' insolation is one of the fundamental in the housing planning projects' development. Currently, two normalized parameters are estimated in Russia: the insolation itself and the coefficient of natural light exposure. These two parameters together govern the planning decisions' adoption, including from the standpoint of the premises and territories' natural disinfection. At the same time, these two parameters make it possible to regulate the spot development and prevent the cases of standards violation. There are several generally accepted types of buildings characteristic of modern cities: group, perimeter, lowercase, free. Each type of building is characterized by its own layout of buildings. Accordingly, each scheme determines the insolation mode and natural illumination of buildings and territories. Mathematical analysis and full-scale experiment will allow to evaluate the advantages and disadvantages of the considered types of residential areas' development. In addition to the planning structure, insolation and natural illumination of territories are affected by the number of storeys in the building. The higher is the number of storeys, the less are the considered indicators. Accordingly, when considering the issues of insolation and natural light, along with the planning structure of residential buildings, attention should be paid to the number of storeys in the building. The theoretical and field studies presented in this work will allow in practice, when developing the new planning solutions, as well as reconstructing the existing buildings, to adopt the type of residential planning that most fully meets the regulatory requirements for insolation and natural light.

Introduction

One of the most important tasks of urban development is the creation of such a development that would provide comfortable and favorable conditions for human habitation. Sunlight is one of the most important factors influencing the formation and organization of urban development. When planning the structure of the built-up residential area, urban planners have a number of tasks to ensure that the future premises and the surrounding courtyard have the sufficient insolation time and ensure the required conditions of natural light (NL).

For residential areas and micro districts are characterized by the different methods of development. They differ in the unequal arrangement of houses in relation to the red line of streets and the construction line.



Relevance

The relevance of this study is very significant, since a sufficient amount of light is necessary for a person to live, and the planning structure of residential areas does not always take this need into account. In the framework of this study, the task is to find out not only the degree of the light environment influence on the planning structure of residential neighborhoods, but also to establish the most optimal system (type) of neighborhoods layout, reinforcing this hypothesis with experimental values.

The object of this study is the light regime (natural lighting and insolation of territories) of the micro districts' existing residential development of in the city of Moscow.

The purpose of the study is to determine the preferred system (type) of the planning organization of the micro district's residential territory, based on the natural lighting and insolation study data of the existing planning decisions' territories.

A lot of scientific works have been devoted to the study of the sunlight influence on humans and urban development. Among them were the works by: L.L. Dashkevich, A.K. Soloviev, D.V. Bakharev, L.N. Gusev, I.S. Sukhanov, N.V. Obolensky, Yu.B. Eisenberg, B.A. Dunaev and others [1].

The scientific relevance of the issue

Currently, in Russia, the sunlight influence assessment on the planning structure of residential development is regulated by two parameters: the duration of buildings and territories insolation [2] and the coefficient of natural light exposure (CNL) [3]. When developing a territory planning project, the insolation regimen should be taken into account especially, since the integrated design should ensure not only the insolation regime of the premises, but also the adjacent territories, on which the areas for various purposes are located (children's, sports, utility, etc.).

The problem formulation

Taking into account modern conditions, housing should not only provide people with a roof [4], it should meet the sanitary and technical standards and requirements. Therefore, one of the fundamental tasks of the residential areas and micro districts' planning and development is to ensure the best insolation and illumination of buildings and construction areas, as well as creating the conditions for comfortable people's living.

The lack of natural light worsens the conditions of visual work and creates the prerequisites for the "solar (or light) starvation" syndrome development in the urban population, which reduces the body's resistance to the adverse factors of a chemical, physical and bacterial nature, and according to recent data, to stressful situations. Therefore, the deficit of natural light and the denaturation of the light environment are attributed to the factors unfavorable for human life.

Theoretical part

The criterion for evaluating variable natural light is the coefficient of natural light (CNL), which is the ratio of the natural light N_M created at point M on a given indoor working surface by diffuse sky light (directly or after reflection) to the simultaneous value of the external horizontal light under the open sky N_H [5]. The CNL value shows the illumination proportion at a given point M of the room from the simultaneously measured illumination of a horizontal surface in an open place under diffuse sky light. CNL is expressed as a percentage. The participation of direct sunlight in the determination of N_M and N_H is excluded. Formula (1) calculates the value of CNL, denoted in the formula as n_M [6]:

$$n_M = \left(\frac{N_M}{N_H} \right) * 100, \quad (1)$$

where N_M – is the natural light created at point M on a given indoor working surface by the diffuse sky light;

N_H – is the value of external horizontal illumination under the open sky.

The concept of natural light coefficient is applicable to the interior of buildings and structures.

Rationing of insolation is currently the main constraint in the developer's desire to use each free area of the city for construction [7].

Insolation is the surfaces' irradiation with sunlight at different angles of inclination [8]. It is one of the main hygiene factors and a natural process that ensures the disinfection of rooms and territories due to the arrival of ultraviolet radiation. In addition, insolation is a factor that affects the psychological state of people. However, the higher the number of storeys of a building and the higher its density, the more strongly the insolation mode is violated [9]. This negatively affects the health of the population, reducing the healing effect of insolation and its bactericidal effect [10].

The requirements for the natural illumination of buildings are established by the Sanitary rules and norms document 2.2.1/2.1.1.1278—03 "Hygienic requirements for natural, artificial and combined lighting of residential and public buildings" [3]. The methodology for calculating natural light is set out in the Building Code and Construction Rules BC 23-102-2003 "Natural lighting of residential and public buildings" [11]. The value of the horizontal external illumination of the territories of residential micro districts is not regulated in any way today.

The issues of the residential premises and territories' insolation are regulated in the following regulatory documents: Sanitary rules and norms 2.1.2.2645-10 "Sanitary and epidemiological requirements for living conditions in residential buildings and premises" [12]; Sanitary rules and norms 2.2.1/2.1.1.1076-01 "Hygienic requirements for insolation and sun protection of premises of residential and public buildings and territories" [2].

During the construction of new buildings and during the reconstruction of the structures, the standards require the fulfillment of certain conditions of insolation for emerging the new buildings and for the existing structures.

The calculation of the insolation duration of the territories with different types of residential planning was carried out in the program SITIS: Solaris.

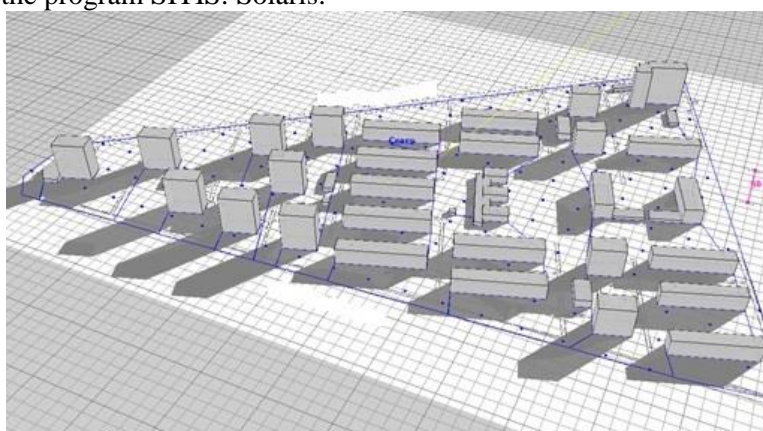


Figure 1. 3D model of the site at 8:00

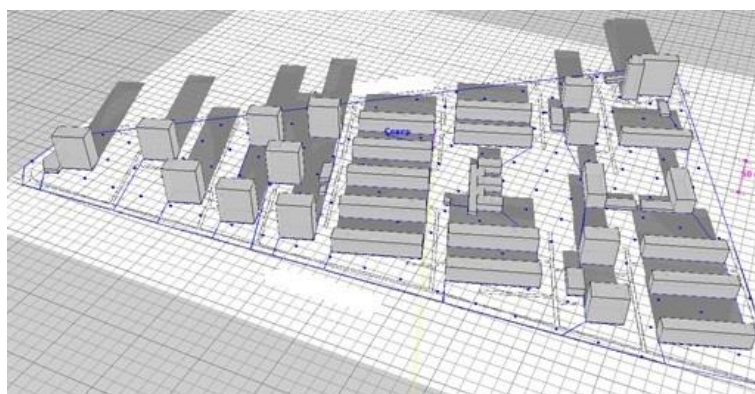


Figure 2. 3D-model of the site at 13:00

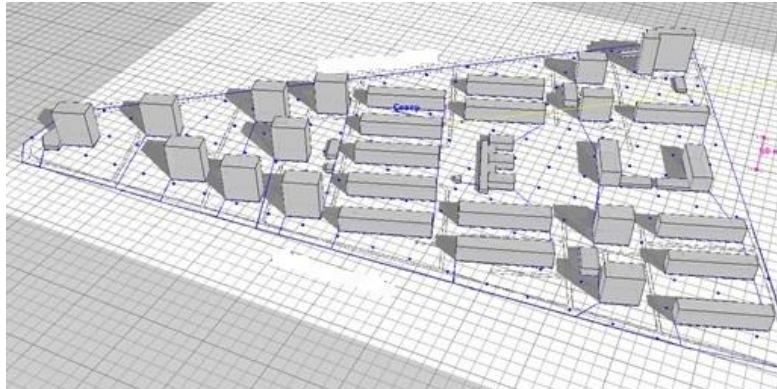


Figure 3. 3D-model of the site at 16:00

Practical relevance, suggestions and implementation results, experimental research results

For each type of the residential area planning decision, the average values of outdoor illumination on the sidewalks, parking lots, green areas and entrance groups of buildings were determined.

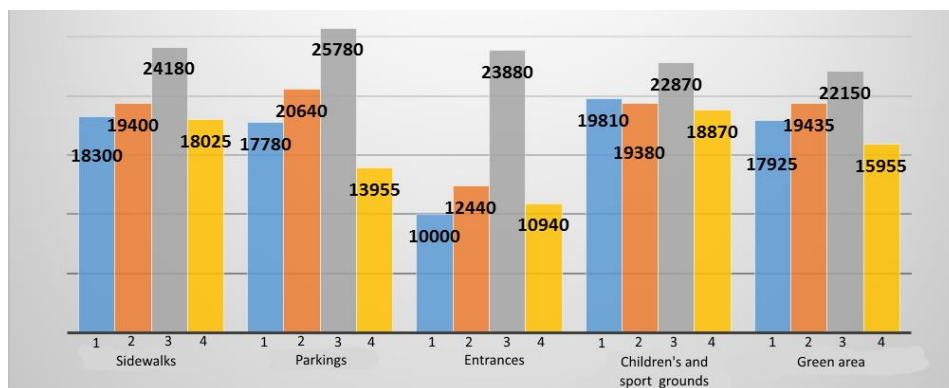


Figure 4. Diagram of the study object's natural outdoor illumination. Development types: 1-group; 2-perimeter; 3-lower case; 4-free.

According to the study object's horizontal illumination experimental study results, it was found that:

- the lowercase type of the residential district development system provides the territory with natural light at all design points equally well in the range of 22150 lx – to 25780 lx;
- the territory receives the least natural light with a free building system ranging from 10940 lx – to 188770 lx;
- the sections of sidewalks, playgrounds and sports grounds, green areas with perimeter and group building systems, respectively, are provided with natural light approximately the same from 17925 lx – to 19810 lx, in the first case, and from 19380 lx – 19435 lx in the second case;
- the least amount of natural light (10,000 lx) is the territory of the residential areas development group system's entrance.

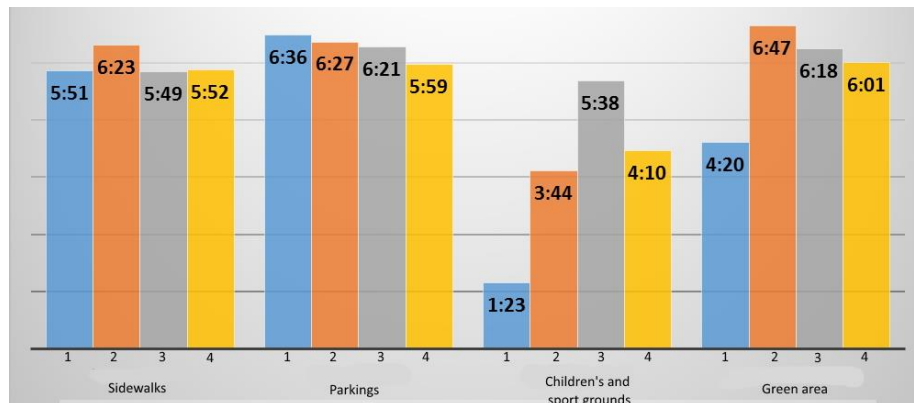


Figure 5. Diagram of the territories' continuous insolation average duration
Development types: 1-group; 2-perimeter; 3-lower case; 4- free.

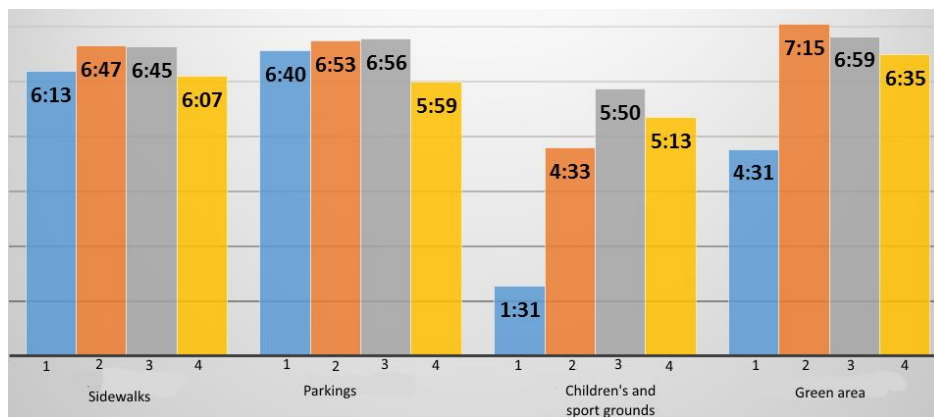


Figure 6. Diagram of the territories' intermittent insolation average duration. Development types: 1 - group; 2 - perimeter; 3 - lower case; 4 - free.

According to the study object's territories insolation duration experimental study results, it was found that:

- the shortest continuous insolation of porches and green areas is observed in the areas with group building 1 hour 23 minutes and 4 hours 20 minutes, respectively, while parking with such a planning decision is best insulated (6 hours 36 minutes);
- the sidewalks are continuously insulated in all areas approximately the same, with the exception of perimeter development: here they are illuminated for 32 minutes longer;
- best of all, the continuous insolation of entrances is provided with a horizontal layout system (5 hours 38 minutes);
- the difference between continuous and discontinuous insolation of all types of the residential neighborhoods' planning decisions is insignificant and amounts to no more than 1 hour 3 minutes (in the case of insolation of entrances with free development).

Summary

Based on the processing and analysis of the data on the study object's territories natural illumination, the sites territories insolation (sidewalks, porches, parking lots, green areas), as well as the children's and sports grounds, the following conclusions can be made:

- from the point of view of providing the best level of natural light, the most preferable system of planning a residential area is lowercase, the average illumination is 23772 lx;

- the preferred planning system of a residential area from the point of view of providing the territories' longer insolation for various purposes (sidewalks, porches, a green zone and parking lots) is line building (the average value of the insolation duration for all territories is 6 hours 1 minute); the perimeter building is not much inferior in duration to it (5 hours 50 minutes);
- the greatest continuous insolation of the children's and sports grounds is provided at perimeter building (307%), the insolation duration at line building is slightly less (271%).

According to the study results, it was found that the line building system of residential micro districts is the most promising for ensuring favorable living conditions for the population, taking into account the illumination and insolation regime of the territories. The possibility of placing the building plan "on the line" makes it possible to choose the optimal orientation of the living quarters from the point of view of lighting and insolation, with the least losses for the lighting environment of the courtyards.

Today, insufficient attention is paid to creating a comfortable and favorable urban environment. Very often (especially with dense residential development), the civil engineers neglect the requirements to ensure the necessary level of illumination and insolation of buildings and territories. In pursuit of an increase in speed and cheaper construction costs, the insolation analysis is not carried out correctly.

The rapidly growing urbanization is changing the intensity and spectral composition of solar radiation at the Earth's surface - due to air pollution, reduced transparency, and significant shading of the territory with dense multi-story buildings.

All this is a factor in the deficit of natural light and the denaturation of the light environment, leading to the creation of an unfavorable environment for human life.

In order to reduce the negative impact of modern construction features on cities, it is necessary to design an urban environment taking into account the illumination and the insolation regime. At the same time, special attention should be paid not only to insolation of the light openings of buildings, but also to insolation of the territories of children's and sports grounds.

The study of the dependence of insolation and illumination on the types of planning systems in residential micro districts can help urban the designers to solve the main problems in ensuring a favorable environment for the population when developing the territorial planning projects. Knowing the features of the existing types of micro districts' planning decisions

taking into account the illumination and insolation mode, as well as the preferred type of development, it is possible not only to speed up the design process, but also to spend more time refining the spatial and architectural-planning decisions of the micro district.

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