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# THE ROLE OF THE SOLAR IRRADIATION PLATE FOR ESTIMATION OF THE INSOLATION REGIME OF URBAN TERRITORIES AND BUILDINGS

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**ABSTRACT**

The article is devoted to the actual problems of modern urban planning – the development of an insolation (solar irradiation) plate and its wide application in the solution of town planning tasks for the summer warm period with the aim of creating a comfortable insolation, light and microclimatic environment in buildings and urban areas.

**Keywords:** insolation, insolation plate, illumination, solar radiation, buildings, buildings, microclimate, comfort of the environment

The purpose of the article is to develop the design of the insolation plate with the purpose of practical application for a qualitative and quantitative assessment of the insolation regime of premises and the territory of urban development for the summer warm period for different geographical latitudes.

Solar radiation has an extremely high biological and hygienic value, is a powerful health and preventive factor, having a positive psycho-physiological effect on a person. In this regard, regulatory documents determine the need to dose insolation of premises, territories and the human environment [1,2,3,4,5].

The effect of insolation on the life and activity of a person can be both positive (additional heating and lighting in cold weather, bactericidal action) and negative (overheating of the environment in the summer, uncomfortable lighting, glare, destroying effect of sunlight) [6,7].

Insolation causes a number of negative reactions on a person, in particular, causes the stress of a person's thermoregulatory apparatus, and leads to a weakening of local and systemic immune reactions, a violation of the cardiovascular system and exacerbation of herpetic infections.

In the summer months, with prolonged irradiation of buildings and the active surface of urban building, a superheating discomfort microclimate is formed indoors and in the building area, which determines the dosage of insolation and sun protection in the premises of residential, public buildings and urban areas [4].

In this regard, in the solution of town-planning tasks, in the process of developing a volume-planning structure of buildings, determining the height and orientation of buildings around the world, the size of the gaps between them, places for children's, economic and other sites, the requirements for the insolation environment must be taken into account, depending on the purpose of the buildings, territories and administrative area.

When developing a detailed design of micro-districts, urban areas, there is an intuitive approach for designing architectural and planning structures of construction, zoning of the territory of free micro-spaces, the formation of elements of landscaping, gardening and small architectural forms often occurs. For this reason, in the summer overheating period, the thermal discomfort of the human environment is created.

For the purpose of assessing the qualitative and quantitative indices of insolation of the summer

**Table. Total Solar Irradiation, W/m$^2$**

| Orientation / hours | Horizontal plane | South | East | West |
|---|---|---|---|---|
| 05 | 89 | 16 | 294 | 41 |
| 06 | 196 | 46 | 583 | 58 |
| 07 | 314 | 78 | 750 | 65 |
| 08 | 455 | 184 | 786 | 74 |
| 09 | 587 | 321 | 734 | 76 |
| 10 | 691 | 447 | 582 | 79 |
| 11 | 772 | 550 | 385 | 85 |
| 12 | 817 | 603 | 196 | 199 |
| 13 | 772 | 550 | 85 | 386 |
| 14 | 691 | 447 | 79 | 582 |
| 15 | 587 | 321 | 76 | 734 |
| 16 | 455 | 184 | 74 | 786 |
| 17 | 314 | 78 | 65 | 750 |
| 18 | 796 | 46 | 58 | 583 |
| 19 | 89 | 16 | 41 | 294 |
| 20 | - | - | 17 | - |

warm period, premises of buildings and territories with a complex space-spatial, architectural and planning solution, the design of an insolation plate is proposed. Insolation plate allows at the design stage to perform preliminary forecasting of the insolation regime and to identify architectural and construction and planning means for regulating the radiation and heat-wind conditions in urban micro-spaces.

Scientific developments in the issues of insolation of cities and buildings are widely conducted in our country and abroad. To this problem, such specialists as architects, hygienists, etc., show great interest, since insolation is the most important natural factor of urban development. A variety of graphs and plates have been developed to estimate the standard duration of insolation in accordance with the requirements for geographical areas [8–17].

The requirements for insolation and sun protection of building premises are carried out in accordance with the provisions of SanPiN and the Code of Rules. The boundaries of the zones in latitudes, the calculated days and the standard duration of insolation, sun protection of living quarters of the apartment, the territory of urban development are presented in the relevant regulatory documents [4,5,18–21].

Consideration of the role of the thermal effect of solar radiation as the determining factor of the overheating of the climatic environment is especially important in the architectural and structural design of buildings and urban micro-territories for the hot season. In connection with this SanPiN hygienic requirements for limiting the excessive thermal effect of insolation on the territory of residential development are defined.

At present, many methods for calculating the standard for the duration of insolation of rooms have been developed, for the insolation period, depending on the range of geographical latitudes established by SanPiN. They should be reduced to the following:

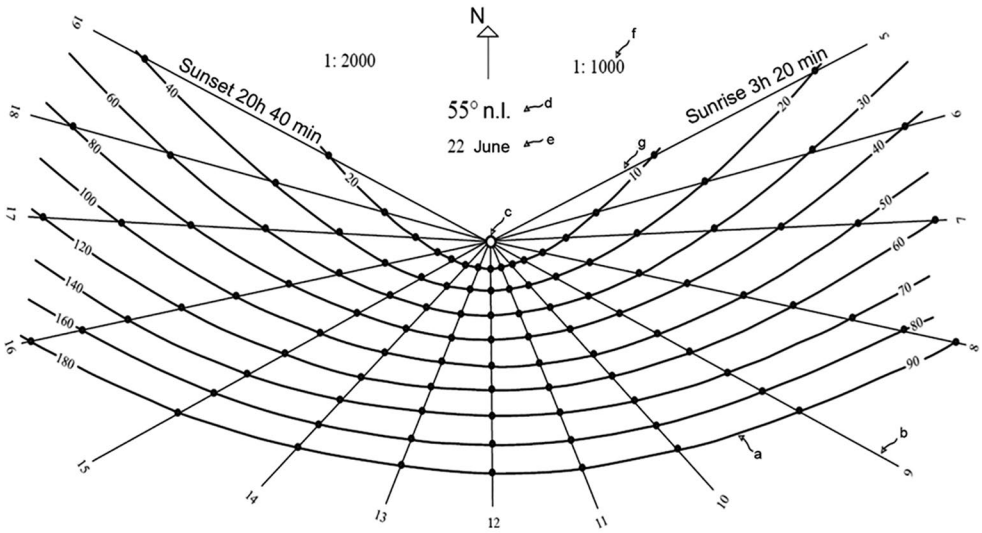



Fig. 1a. Insolation plate for the day's sun (main part)

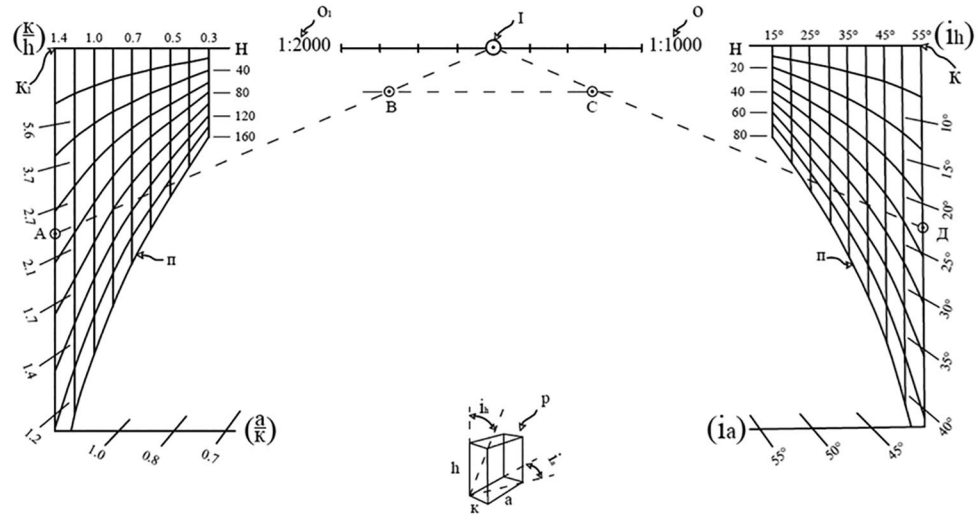



Fig.1b. Insolation plate (overlay part), insolation angle of the window

– A method of calculating insolation, which does not simulate the natural course of insolation on the building plan, and definition of qualitative and quantitative indicators is made by formulas and tables;

– A calculation method that does not simulate the natural course of insolation on the building plan, which gives insolation indices by means of charts, diagrams, graphs, and subsequent calculations by formulas and tables;

– A method of calculation, simulating the natural course of insolation in the building plan, which allows using instruments to determine the qualitative and quantitative indicators of the sun's energy, mainly for equal-floor buildings;

– Ways of calculation of insolation by computer programming, therefore, algorithms and computer programs that allow us to calculate only the qualitative characteristics of insolation have been developed.

Existing insolation plates, instruments and programs have a certain scope and are not universal for solving simultaneously a variety of architectural and spatial planning and voluminous spatial practical tasks in quantitative and qualitative estimation of insolation. Each of the instruments and techniques is acceptable at the boundary of the zones according to the geographical latitudes of the normalized period of the year, to predict the insolation regime in the relevant area of architectural and construction design, depending on the specific case of the spatial planning structure of urban buildings, such as the number of floors of buildings, the gap between them, orientation, zoning micro-territories, shading elements, landscaping and improvement.

It is also noted that the calculation of the qualitative and quantitative characteristics of insolation of

the warm period of the year in the above methods and instruments remained out of sight.

Along with the existing devices, the proposed practical application of the insolation plate allows to calculate both the qualitative and quantitative indices of insolation of the warm period of the year on the plotted layout of the multi-storey architectural and planning project at the design stage without complex graphic constructions.

The operating principle of the insolation device is determined by the laws of interaction of the visible movement of the sun in the sky and the position of the insolated object on the surface of the earth.

The insolation plate design kit for geographic latitudes is basing on solar geometry, i.e. the movement of the Sun in the sky in the summer warm months (Fig. 1a, b). The insolation plate was developed on the basis of astronomical tables, geographic data, reference nomograms and data of construction climatology SNiP and SP.

So, the insolation device of the plate type consists of two parts, the basic transparent fixed, characterizing the daylight course of the sun (Fig. 1a), and the overlay transparent moving around the central point, which determines the insolation angle of the window (Fig. 1b).

The main part of the device consists of a set of designs of individual transparent plates with an interval of 5° for the following latitudes 40°, 45°, 50°, 55°, 60° n.l., characterizing the daytime course of the sun (Fig. 1a). To the main part there is an overlay transparent part that takes into account the horizontal and vertical insolation angles of the window when calculating the qualitative and quantitative indices of indoor insolation (Fig. 1b).

Each insolation plate is acceptable in application for the geographical belt 5°, for example, a plate for 55° n.l. is used in the belt from 52°30[1] to 57°30[1]n.l.

The centred points **C** and **I** of the moving part of the plate are aligned with the inspected building object, made on a scale of 1: 1000 or 1: 2000.

Calculation of the duration of insolation of premises of buildings of different number of storeys, in hours, is made on the building plan by visual overlapping on the facade line of the building, fastened to the central points of both plates, coordinating the direction of the north sign of the insolation plate with the planning layout of the building. In this case, the quantitative characteristic of solar radiation of the insolation period, in W/m$^2$, using the data of the table attached to the main part of the plate is calculated.

Calculation of the duration of insolation of the territory of a multi-storey urban development is visually superimposed by the central point of the main part of the insolation plate to the point under study planning layout of the building, with the subsequent addition of the data of the table of arrival of solar radiation during the insolation period. The main part of the insolation device is to identify zones of active insolation of the territory of urban structures and to build an envelope of shadows from buildings of various-storey buildings, a shading area from greenery of various types in the hot extreme period of the year.

The design of the insolation plate is designed to assess the summer insolation regime of the facade and premises of buildings with different orientations, the presence and absence of a balcony, loggias, sun screens in a multi-height building, a building site with various means of sun protection and landscaping with large-scale plantings.

On the insolation plate, the insolation time is given by mean solar time.

Calculation of total solar radiation coming to the horizontal surface of the territory, roofs of buildings and vertical walls of buildings of different orientations for the insolation period is made according to the data of the table attached to the main part of the insolation plate.

In the design of an insolation plate, when calculating the quantitative and qualitative indices of the insolation of building premises, facade walls, building area, the intensity of total solar radiation, depending on the geographical latitude of the terrain, the time of the June day, the location and orientation of the surface, the height of the shading buildings, the state of the atmosphere and altitude above sea level are taken into account.

The data on the thermal solar radiation of the insolation period, determined from the table, are taken into account in the planning, building up of newly constructed and reconstructed micro-districts and cities, the orientation and arrangement of buildings, the shaping of buildings, the internal layout of buildings, the choice of dimensions, the type and arrangement of light barriers, the design of sunscreens, constructions for heat resistance, use of solar panels, landscaping, garderning, watering and sun protection of territories.

In the development and reconstruction of general plans for cities, settlements, as well as detailed planning projects and schemes for planning the organization of land and territories, the insolation plate allows to predict the qualitative and quantitative characteristics of the insolation regime of the urban area with the identification of zones and facades of buildings with active insolation, which allows us to estimate the comfort of the microclimate.

For practical purposes, at the stage of drawing up a detailed urban planning scheme aimed at improving the comfort of the microclimatic, light-climatic and bioclimatic environment, the insolation plate allows us to make practical design and research works according to the following scheme:

– An insolation chart is constructed for an urban building fragment plotted on a topographic base by means of an insolation plate, including an insolation graph with an isoline of 6, 8, 10, and 12 hours of insolation, and the intensity of arrival solar energy for these periods is calculated;

– An envelope of shadows is constructed with the identification of zones with the longest duration of insolation, shading and heating of the surface of the territory, insolation of facades and premises with the longest duration of insolation;

– A plot of shadows from large-scale tree plantations used to compile a dendrological plan is constructed, their location and density are determined taking into account the shading effect aimed at improving the microclimate;

– A purposeful functional zoning of the urban development area is carried out, depending on the insolation condition;

– When building planning, the orientation of buildings with the definition of gaps between them are correcting at the design stage.

The insolation plate has a wide application in the solution of town planning tasks for the summer warm period. Experts highlight the role of the insolation plate in calculating the duration of insolation of premises and the territory of buildings, the climate of buildings, assessing the energy efficiency of buildings, determining the thermal loads of the building's heat-and-cooling systems, calculating the heat resistance of the enclosing structures, assessing the microclimate of the premises, choosing effective protective measures to combat summer overheating in the premises and on the territories of building, the choice of the orientation of buildings and their window openings on the sides of the horizon, in solving problems in the field of light under different conditions of formation of interconnected zones of irradiation and shading in architectural planning and volumetric spatial formations of the city, in the design of solar protection systems and solar systems, as well as in the design and construction of ecological buildings and cities, planning, building, landscaping, gardering and watering of urban areas.

Summing up, it should be noted that the use of an insolation device of the plate type allows solving a number of scientific and practical town planning tasks by calculating and assessing the quantitative and qualitative characteristics of the insolation regime aimed at improving the ecological environment of urban buildings and buildings in the warm period of the year.

For the purpose of a wide application of the insolation plate, methodical instructions for describing the device, the principle of operation and application of the insolation plate in design practice have been compiled. The application of the insolation plate in practice was tested during the development of the general plan of the city of Buka in Uzbekistan and the reconstruction of the city of Dushanbe in Tajikistan, as well as in the preparation of graduation master's works.

## REFERENCES

1. Humaner P.I. The Study of thermoregulation in hygiene and physiology of labour. M.: Medgiz, 1962, 231p.

2. Gubernskiy Yu. D., Litskevich V.K. Human Dwelling, M.: Stroyizdat, 1991, 227p.

3. Banhidi L. (translated from Hungarian) Thermal microclimate of premises (calculation of comfort parameters by human heat sensations), M: Stroyizdat, 1981, 247p.

4. Sanitary Rules: SanPiN. 2.2.1/2.1.1.1076–01: Hygienic requirements for insolation and sun protection of residential and public buildings and areas.

5. System of urban planning rules: SP 42.13330.2011. Planning and construction of urban and rural settlements (Updated version of SNiP 2.07.01–89*), Russian Ministry of Regional Development, 2010.

6. Eizenstat B.A., Lukina L.P. Bio-climate and microclimate of Tashkent. L.: Hydrometeoizdat, 1982, 128 p.

7. Markus T.A., Morris E.N. Buildings, climate and energy (translated from English), L: Hydrometeoizdat, 1985, 542 p.

8. Dunaev B.A. Insolation of the dwelling, M.: Stroyizdat, 1979, 102 p.

9. Dashkevich L.L. Methods of calculation of insolation in the design of industrial buildings, M: Gosstroiizdat, 1963, 526 p.

10. Maslennikov D.S. Basics and methods of calculation of the conditions of insolation in mass dwelling construction. The author's thesis of dissertation for Ph.D. M.: 1968, 28 p.

11. Obolensky N.B. Architecture and Sun, M.: Stroyizdat, 1988, 207 p.

13. Twarowski M. The Sun in Architecture (translated from Polish). M.: Stroyizdat, 1977, 288 p.

14. Architectural Physics: Textbook for universities: Special. "Architecture", by Litskevich V.K., L. I., Makarenko, I.V. Migalina, etc.; Under the editorship of N.V. Obolensky, M.: "Architecture-C", 2007, 448 p.

15. Olgyay V, Olgyay A. Solar Control and Shading Devices, Princeton University Press, New Jersey, 1957, 236 p.

16. Grimmond C.S.B. Progress in Measuring and Observing the Urban Atmosphere // Theoretical and Applied Climatology, 2006, Vol. 84, № .1–3, pp. 3–22.

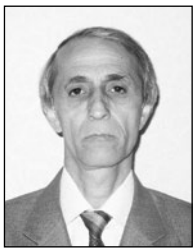
17. Cocchia, A. Smart and Digital City: A Systematic Literature Review. R.P. Dameri and C. Rosenthal-Sabroux (eds.), Smart City, Progress in IS, Springer International Publishing Switzerland, 2014, pp.13–43.

18. SanPiN2.1.2.2645–10 " Sanitary and epidemiological requirements for living conditions in residential buildings and premises."

19. SP 54.13330.2011 Residential apartment Buildings.

20. SP 160.1325800.2014 Buildings and complexes multifunctional. Design rules.

21. SP 118.13330.2012* Public buildings and structures.



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