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The solar component in the context of the inhabited areas microclimate regulation

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Summary. Summer overheated modern city deteriorates living conditions in it. For this purpose, the climate formation is considered in three adjacent spatial levels: macroclimate of geographical area; mesoclimate of a certain location (southern slope of the mountain, river valley, the sea coast); microclimate of two-meter surface layer (at the level of the human body). These levels of different spatial scale have similar mechanisms of climate formation. The radiation temperature and wind conditions of the area are the main causes of the overheating. The specified information proposes to research the solar radiation and the surfaces to accumulate it. The urban landscape is predominated over by the surface, which significantly accumulate heat. Hence the surface layer of air in the city receives three times more heat than in the natural environment. Thus, microclimate is formed in the streets, squares, in a housing estate and city parks under the natural and city planning factors. The found that for balancing and softening of microclimate conditions for living and of effective impact on the heat, humidity and aeration regime of the modern city, it is desirable to achieve a ratio of 1:1 between its planting and artificial surfaces.

Key words: climate, insolation, residential area, architectural and planning regulations, environmental barrierless environment.

INTRODUCTION

A modern stage of global development is defined by hastily growing cities, population conurbation, agglomerating transport, industry, noxious emissions in the environment. Climate warming and the said global tendencies impair the urban living conditions, while in 2008, according to the UN, 50% of the planet population lived in cities, about 70% - in Ukraine. In the said context, architecture and city development should contribute to resolution of a problem to provide comfort for human existence. Here, of use can be a positive experience of modern architecture – one of the “most illustrative and materialized manifestation of the social spiritual life” [1].

In the ambient environment, continuous in time and space, residential areas and dwelling are formed influenced by interaction of energy-mass systems, irregularly distributed on the land surface. This is primarily the natural climate of a certain locality. City development objects, transforming the energy and mass flow, create a new environment, where a local microclimate is formed. In the course of vital activity, people move from one environment into another. Thereat, influenced by a beneficial effect of a natural habitat, they try to regulate the urban environment accordingly, too. People’s reactions related to environmental changes, especially when it’s hot in summer, is mostly physiological. That’s why almost all countries – members of the World Meteorological Organization (WMO) – have prepared National reports regarding climatic changes, including on peculiarities of these changes’ effects on public health. These countries have also prepared National action plans to reduce risks related to effects of the said changes. Thus, in France, where over

35 thousand people died due to the 2006 heat, a special action plan has been issued envisaging creation of special recreation rooms for elderly people with comfortable microclimate, and propaganda of protective measures during summer overheat [2, 3, 4].

Climatic change becomes more and more appreciable adverse environmental factor, significantly and negatively affecting the comfort of people's stay in urban conditions in summer. When it is hot, public mortality rate is growing, especially among elderly population [2, 3]. According to Ukrainian scientists' forecasts, in 2010-2060, atmospheric temperature during the warm semester in Ukraine will rise, while the amount of precipitations and humidity factors will reduce [5]. Ukrainian legislation defines city planning as activities to create and maintain a sound human living environment, providing permanent, social, economically and environmentally balanced development of inhabited localities and adjacent territories, nature conservancy and rational nature management. Therefore, of especial significance is search of the corresponding architectural and planning measures enabling local alleviation of microclimate within limits perceptible for a man [6, point 10.31]. In this context, there emerges a necessity to generalize microclimate formation factors for residential areas and warmth-sensing indicators that would allow assessing the degree of thermal discomfort.

It should be mentioned that as regards formation of a comfortable and ecologically barrier-free environment, traditional microclimate division into "external" – of residential areas and "internal" – indoors, is not essential as people move freely from one space to another. Yet, while indoors or in vehicles the said matter is to some extent regulated by technical climate control means, in terms of near-house areas this issue still remains topical.

PROBLEM FORMULATION

Groups of buildings, underlying surface (verdured, paved, inundated), sunlight, radiation, wind flows, temperature etc. interact in urban environment. Such agglomeration both creates a protective system of human existence within nature, providing its own form of a changed environment – city microclimate, and dissociates it from nature. Surrounded by buildings, people are affected by the changed environment and city in general [7].

Architecture and city development are important landmarks of human development. Public mental and physical health depends on the coziness, broadly speaking, of a city, building or structure, on the extent of harmony in their connection with the natural habitat. Under conditions of climatic changes this issue becomes especially crucial.

In terms of architectural and city development ecology, this matter is connected to the Sun and solar radiation, being the first and the most important climate-forming (from Greek "klima" - land surface inclination towards the Sun [8]) factor and determines the nature of the artificial environment. A.I. Voyeikov, prominent Russian meteorologist noted than the Sun is the first cause of all processes forming the climate and it has a decisive influence on formation of a comfortable environment for human existence, and architecture [9]. Historical and culturological background confirm that urban climate and microclimate issues have long attracted the attention of architects and city planners.

Vitruvius's works paid great attention to effect of climate and recommendations on its recording. It started with stating the place selection principles and city planning in order to avoid wind funnel formation, take into account southern winds and heat, air humidity. A full chapter was dedicated to climate as a deciding factor in determining the building style. Thoroughness of climate accounting is confirmed by his phrase that "…cities and buildings in the south should be designed and built according to warm climate, doing this quite differently in the north" [10]. He warns of solar radiation, reflected from dry land or water, due to which in a hot climate a building will be subject to “double sun”, speaks against building cities in valleys due to increased humidity, decreased aeration and sun rays reflection, creating excessive heat [7; 11, 12].

A direct consequence of climatic conditions are architectural peculiarities of cities in southern dry regions, which always were a kind of "self-shading structures", and buildings – of original "thermoses" with solid walls, scarce small windows, enclosed compact planning of courtyard and narrow lanes. Damp regions, on the contrary, are marked by free planning, “breathing” translucent walls, well-ventilated areas [10].

Alberte and Palladio believed that "…width of streets, height of buildings and sizes of windows should be determined taking into account the orientation and depth of premises…”. Corbusier undertook a serious research of design issues and wrote of a necessity to use solar and wind influence as forming factors when planning cities, stating that "sun is an important material for an architect…" [10].

Wright used solar geometry in designing a number of buildings. Thus, in Sturges’s buildings, eaves’ sizes depended on degree of sun rays’ inclination. Climate also ranked first in Gropius’s design concept. Many of his works take into account degree of sun rays’ inclination in various periods of the year.

Today, all cities of the world have glass facades with light curtain walls, taking no account of local climatic manifestations. Later, Corbusier himself ascertained that in summer one should fight "…disastrous inrush of sun". He persuaded the committee of architects in 1933 in Athens to approve city development principles with regard to the fact that "urban planning materials are: sun, space, vegetation, steel and concrete, just in this strict order and hierarchy" [5, 11].

A major part of Rapoport’s works is dedicated to consideration of natural surroundings, climate and social technology as deciding factors in selecting a building shape. He highlights that when forms and even structures are transferred unchanged from one climate to another, there are often incorrect, in terms of climate, constructions and space. Space language should provide basic notions of external and internal environment and should reflect their non-separability. In this context, scientific analysis of climate is of great importance. However, today architectural developments and planning still lack scientific methods of using academic climatic data [7].

External climate, internal environment of buildings and structures, and human response thereto are interconnected. The main means of people’s adaptation to environmental changes, depending on location – in- or outdoors – is clothes, while the space of their stay is integral. Among other changing characteristics, such space has thermal ones. As influenced by energy and mass, certain conditions are created in any point of space, depending on radiation and convectional characteristics of the area. Radiation conditions of residential areas is determined by climatic factors and nature of landscape, presence of natural or artificial objects, type of development [7].

Due to Galileo having invented the thermometer (1593) and Torricelli – the barometer (1644), it became possible to measure two main microclimate parameters - temperature and pressure. Results of measurements initiated in 1806 in cities around London and published by Howard in 1818 showed material dissimilitude of urban microclimate [7, 10].

As previously mentioned, prominent architects Vitruvius and Alberte not only had a professional command of methods of assessing microclimate, insolation and sunlight protection, but also improved and enhanced such skills. Suffice it to remember Vitruvius’s famous “Sun’s analemma”, forming the basis of all modern graphics for insolation and sunlight protection estimation [10].

Key climatic factors affecting a city development solution are radiation-temperature and wind pattern of the area. Analysis of radiation-temperature conditions envisages research of direct solar radiation intensity given various atmosphere transparency, and surfaces having various orientation [13].

An important factor of microclimate formation is insolation (from Latin – put to sun), which in turn is total solar radiation of surfaces and spaces. Insolation has dual effect on the man and the environment. It is beneficial on a sanitary-hygienic viewpoint, and thus economically profitable. Then, it is necessary to provide sunlight access to urban development. Yet, it causes light discomfort and overheat as well [13].

Radiation and insolation patterns are determined by total solar radiation, consisting of direct solar radiation produced immediately by the sun, diffused - produced by the whole horizon; shortwave solar radiation reflected by surfaces, and long-wave (thermal) radiation of heated surfaces [13]. Intensity of radiation emitted and reflected by the surface, radius of its effect are determined by the quantity of received solar radiation, and this surface's ability to reflect it (albedo). Intensity of vertical surface radiation is determined by its orientation. Thus, if we take radiation of a south-oriented surface as 100 %, for east and west surfaces it will be 130 %; east northwest and west northwest - 128 %; east southeast and west southeast - 137 %; northwest and northeast - 106 %; north northeast and north northwest - 85%; north - 65% [12]. Therefore, the walls facing east southeast and west southeast are subject to most radiation.

In southern cities, less favorable conditions exist for walls turned to the west and southwest, as great intensity of their radiation is usually connected with the highest daily atmospheric temperatures. Therefore, these walls have the highest surface temperature as well. A difference between surface temperatures of the south- and west-oriented walls at the time of their maximum radiation may be up to 6°C. The effect of surface-reflected radiation in southern cities develops on 4-5 m of the distance from the surface at southeast and south orientation; – 7-8 m at southwest; - 9-10 m at west; – 5-6 at northwest. The reach of heated surfaces' thermal long-wave radiation is somewhat greater. Thus, at western orientation it reaches 15-16 m [11; 12, 10].

An idea of insolation standardization emerged in late 19th century. It was confirmed in Erisman's research findings - bactericidal effect of direct solar radiation on pathogenic bacteria's reactivation depending on ultraviolet radiation doses accessing residential premises. Due to this research, insolation standards were first set in Russia in the 1940-s (V.K. Belikova, N.M. Dantsig) – starting with 3 hours of direct solar insolations, this standard was later differentiated depending on a geographical latitude of the area [14]. The first principle of the previously mentioned "Athenian Charter", setting forth the fundamentals of city development, was full provision of healthy dwelling for people, namely, space, fresh air and sun [15].

Direct solar radiation is much more intensive than diffused and reflected so it has the decisive role in assessing insolation distribution in qualitative and quantitative indicators in built-up areas and premises. Direct solar radiation in urban development is regulated by existing sanitary norms for insolation and the relevant paragraphs of the State Construction Norms (SCN) [6].

According to the sanitary and zoning standards valid in Ukraine (Sanitary Rules and Norms (SRN) 2.2.1/2.1.1.1076-01, SCN 360-92**), location and orientation of residential and public buildings, preschool institutions, comprehensive schools should provide insolation duration in residential premises and areas, determined by sanitary standards for a certain period of time in hours, in accordance with regulatory requirements for each category of objects and areas for the period from 22 March till 22 September [6, point 10.30]. Standardization is performed with regard to climatic peculiarities of the design area and nature of development. Normative requirements are achieved by corresponding location, orientation, planning of buildings and areas. For the purpose of insolation accounting in architectural design and city development planning, it is defined using various graphical methods, physical simulation, analytical estimation and computer programs [14].

METHODS OF EVALUATION

Valid insolation standards are based on research of insolation length for premises, conforming to the mean annual dose of total solar radiation. As regards territory, such researches are few and they are mostly sanitary-hygienic and engineering-oriented, aiming to ensure a necessary minimum of solar radiation in residential areas. Their architectural planning standardization should be aimed at providing comfort of human existence in modern cities and regarding regulation of summer overheat – at preventing temperatures crossing the admissible maximum? But what is this maximum?

Works by B. Dunayev, D. Maslennikov, L. Orlova, O. Sergeychuk made a great contribution in methods of insolation assessment [10, 12]. At the Chair of City Construction of Kazan University L. Orlovska conducted a research regarding determination of radiation conditions assessment indicators in residential development territory in terms of the necessary minimum provision. These were energy indicators based on accounting of total radiation doses. It was determined that in shielding development spaces a reliable comparative assessment of the built-up area radiation conditions may only be received based on analysis of yearly and season radiation doses. Regularities of solar radiation exposure in annual cycles allowed us determining a formation mechanism of zones with various degrees of area shielding, limit (by technical-economic indicators) gaps between tower blocks - 1h and lengthy - 2h (where h is building height), limit of insufficient insolation zone by shielding degree isoline ŋ=0,5 (ŋ - shielding degree) as estimated value, and determining corresponding astronomically possible yearly and season radiation doses for the area. The examined method of limits determination for insufficient insolation zones allows obtaining a graphical image of area insolation for the year and to implement the necessary insolation indicators according to SCN [16].

Radiation condition assessment includes background characteristics as well: flow intensity of direct and diffused radiation affecting horizontal and vertical surfaces, as well as analysis of radiation flow transformation inside the city - solar radiation influencing inclined surfaces of various orientation, mutual radiation of development elements. Near insolated planes temperature and radiation conditions in summer become much worse, increasing the urban environment overheat. Intensity of emitted and reflected radiation and distance of its adverse effect is determined by the quantity of received solar radiation, these surfaces' albedo [12].

Territorial radiation image may also be obtained by drawing an insolation map using B. Dunayev's insolation line [9]. The said method is as follows: a mesh of check points is set on a square grid in the residential development area; insolation duration value is determined for each of them and "shade envelopes" are built from buildings for each hour of the day, followed by tracing insolation duration isoline. There is a method of presenting insolation graphical image in the area by D. Maslennikov, based on use of DM-55 light surveyor, that allows determining insolation duration for any month and amount of energy received for a certain time interval, by applying a device with a corresponding scale on the development drawing [12]. Based on obtained maps, the place and degree of the territory thermal pattern's regulation are determined.

Heretofore, greater attention has been paid to residential insolation conditions and lesser - to insolation of areas. Main attention has been drawn to shape, construction and sizes of area lights in buildings, their orientation according to sides of the horizon, location with respect to windows of buildings elements (balconies, loggias, eaves, protrusions, screens, venetian blinds), surrounding residential and communal buildings. However, under summer overheat conditions, the issue of sunlight protection of territories, building walls, and structures from excessive insolation becomes more topical. Especially important here becomes the problem of shading planes and spaces in residential development.

This requirement to arrangement of a continuous yet variable in time and space single environment for human existence in the city, though contradictory at first sight, should be taken into account both at planning organization of residential areas in general and at planning, landscape gardening and rehabilitation of its separate functional elements. Norms and rules for insolation provision at residential areas primarily concern places directly used by the public: children's playgrounds; sidewalks and alleys; swimming pool locations, gaming facilities, recreation benches etc. Normative insolation dose of separate space elements, as well as timing and necessary shading area under summer overheat conditions should be determined in accordance with these elements’ functional purpose and operating mode [6, 12, 17].

ACTIVITIES REGULA

For the purpose of children UV irradiation, children's playgrounds should be insolated during morning hours and in the afternoon, especially during summer overheat, require sufficient shading. Therefore, the structure of such sunscreening facility should create conditions preventing overheat of the body and at the same time providing maximum use of solar energy for medical purposes [10]. The said insolation pattern should also determine tree planting procedures along sidewalks depending on their orientation towards sides of the horizon. In observing the insolation pattern standards, subject to provision of sunlight protection of a sports ground, located in a residential development, one should take into account hours of its use after studies or work. Usually tree planting is envisaged with regard to ground shading in the afternoon. Planting sites and sorts of trees should be specified subject to leafage shade projections during hot hours [12].

Nowadays, these factors are especially significant in developing planning solutions for residential areas. When tracing pedestrian routes, locating children's playgrounds, other spatial elements used by the public, it is necessary to take into account proximity of surfaces, reflecting or emitting solar radiation. Under environmental overheat conditions in combination with low wind speed (still-air conditions), there is a problem of ventilation intensification - "wind capture". Under such conditions, the development planning organization should ensure optimal ventilation terms for the residential area by rational organization of street and pedestrian route arrangement (orientation, profile), observing optimal correlation between built-up, paved, verdured and inundated surfaces. A variety of planning solutions as well as difference of natural climatic conditions of cities determine a necessity to search for optimal insolation and sun protection pattern for the residential area in each specific case [12].

As noted previously, besides direct sun rays (insolation), radiation reflected and emitted by surfaces is of great importance during planning arrangement of residential areas. Its role grows during hot season of the year due to high intensity of direct solar radiation. Limited access of sun rays to surfaces and spaces is reached due to corresponding use of development elements and small forms, microrelief, planting, aquatic areas, fountains, special structural devices - horizontal sun breakers along facade, vertical blinds, screens, eaves, balconies, preventing wall surface overheat [12, 18, 19]. Thus, for instance, swimming pools located at maximum insolation area absorb up to 5400 kcal/m2/day, and only about 600 kcal remain to increase atmospheric temperature [13]. An expedient means to reduce duration and quantity of house area insolation and decrease heat on underlying surface becomes separation of yard space with screens of twining plants or stripes of high-leafage broadleaf trees.

Architectural-planning measures of insolation regulation unite means related to development composition on the residential buildup general layout, planning of buildings and structures, land improvement. Architectural-structural measure cover shading elements of buildings, sun-protective glass-ware and films, sun-protective stationary and mobile devices for territories. We may also distinguish a group of technical means providing artificial microclimate [10].

CONCLUSIONS

In all terms (sanitary-hygienic, functional-planning, structural, esthetic, economic) sunlight protection is an integral and effective architectural element. In bioclimatic aspects of environmental factors important is comfort of human heat sensation. Vigorous activity of a man mainly occurs at daytime, so for city development it is more expedient to take into account the nature of bioclimatic conditions, typical of daytime. The said assessment methods and insolation regulation measures are crucial for daytime under summer overheat conditions.

Under existing conditions, requirements regarding improvement of human ambient environment returned methods and means based on efficient use of useful properties of natural components: sun, wind, water, vegetation. The above-mentioned meets environmental tasks and forms “new ecological architecture” (architectural bionic, solar architecture, climate forming architecture).

Now, when the urbanization process captured the world, the issue of harmonization between the society and nature for the purpose of preserving ecological balance and creating a favorable living environment for people becomes extremely topical.

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СОЛНЕЧНАЯ СОСТАВЛЯЮЩАЯ В КОНТЕКСТЕ РЕГУЛИРОВАНИЯ МИКРОКЛИМАТА ЖИЛЫХ ТЕРРИТОРИЙ

Аннотация. Летний перегрев современного города ухудшает условия проживания в нем человека. Формирование климата города рассматривают сегодня на трех смежных пространственных уровнях: макроклимата географической зоны (лесостепь, полесье); мезоклимат определенного региона или места (морское побережье, долина реки, южный склон горы); микроклимат на уровне организма человека (в двухметровом приземном слое). Эти уровни различной пространственной шкалы имеют схожие механизмы формирования климата. Основными факторами перегрева является радиационно-температурный и ветровой режим территории.

Предполагается исследование солнечной радиации и поверхностей, которые ее аккумулируют. Наземный слой воздуха в городе получает втрое больше тепла, чем в естественной среде. На улицах, площадях, в жилой застройке и парках города под влиянием природных и градостроительных факторов формируется свой микроклимат, а микроклиматические условия могут регулироваться и архитектурно-планировочными средствами. Для балансировки микроклиматических условий и эффективного воздействия на инсоляционный, тепловой, влажностный и аэрационный режимы современного города, желательно достичь пропорции 1:1 между его искусственными и озелененными поверхностями.

Ключевые слова: климат, инсоляция, жилая территория, архитектурно-планировочное регулирование, экологически безбарьерная среда.