

**COMFORTABLE LIGHT ENVIRONMENT IN ARCHITECTURAL DESIGN****<sup>1</sup> Vasylenko O. B.,**

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**Abstract.** In the XXI century, a comfortable light environment in architecture is becoming a category associated not only with a specific material space. When designing architectural objects, it is necessary to take into account the interests of different groups of citizens united by public spaces. Creating a comfortable environment is associated with the understanding of personal freedom and the problem of creating conditions for the development of an open society. The article presents the basic principles in the field of “environmental design”, outlines the methodological basis for the study of the complex of lighting means in architectural systems and describes in detail the general methodology for studying the “light component” of architectural systems. The study contains methods and criteria for assessing the lighting of architectural systems and a methodology for studying the formative and comfortable functions of light in architecture. Light has a significant impact on the architecture of buildings and structures, shaping the proper level of object quality, cost-effectiveness of solutions and artistic expression. The appropriate level of lighting in buildings is an important prerequisite for creating favorable conditions for human life, for increasing their creative and productive activity. The analysis of scientific papers allowed us to identify a number of unresolved issues: a general methodology for studying the “light component” and the methodological basis for studying the complex of lighting means in architectural systems has not been improved. Thus, the methodological basis for the study of the complex of lighting means is in the field of urgent issues of architectural systems. One of the main factors that shape the parameters of the light environment, indoor microclimate, and insolation conditions is the legislative regulations presented in the Laws of Ukraine: “On Environmental Protection” of 1991, ‘On Architectural Activity’ of 2012. The relevance of the topic of this work is due to the need to improve the scientifically based methodological basis of the study, taking into account modern lighting means.

**Keywords:** urban development, architectural education, comfortable environment, urban improvement, natural and artificial lighting, complex of lighting means, research methodology, evaluation criteria, interior and exterior spaces, architectural environment, exterior, interior, comfort of the light environment.

**Introduction.** The modern problems of ensuring a high-quality architectural environment in cities, psychological comfort for people's life, effective use of the aesthetic potential of natural and artificial light, and innovative industrial lighting technologies are extremely important. Light has a significant impact on the architecture of buildings and structures, shaping the proper level of quality of objects, cost-effectiveness of solutions and artistic expressiveness in interaction with them. The appropriate level of lighting in buildings is an important prerequisite for creating favorable conditions for human life, for increasing their creative and productive activity.

One of the main factors that shape the parameters of the light environment, indoor microclimate, and insolation conditions is the legislative regulations presented in the Laws of Ukraine: "On Environmental Protection" of 1991, 'On Architectural Activity' of 2012.

The relevance of the topic of this work is due to the need to improve the scientifically based methodological basis of the study, taking into account modern lighting means.

**Analysis of recent research and publications.** The main studies in the field of solar radiation and insolation theory in architecture are scientific works: M.V. Obolensky, V.O. Belinsky, M.M. Gusev, N.N. Kiireev, F.F. Erisman, A.N. Rimsha, V.G. Makarevich [3], V.M. Firsanov, R. Hopkinson, C.L. Coulson, E. Nieman, A. Olgay, P. Peterbridge [10], H. Ronge, J. Graška.

Among the important scientific developments that formed the basis for determining the methodology of this study, we should highlight the works: O. Serhiichuk, O. Pidhornyi, V. Urenov, M. Demin, O. Sleptsov, T. Panchenko, L. Kovalskyi [4], V. Kutsevych, I. P. Gnes, V.O. Timokhin, V.V. Tovbych, G.I. Lavryk, L. Berg, T. Kuhn, G. Ropol, J. Stengers, J. Tinbergen, A. Toibney [14].

The analysis of scientific papers allowed us to identify a number of unresolved issues: 1) a general methodology for studying the "light component" in architectural systems has not been identified; 2) the methodological basis for studying the complex of lighting means in architectural systems has not been improved. Thus, the methodological basis for the study of the complex of lighting means is in the field of urgent issues of architectural systems.

**Statement of the objective.** In the broadest sense, architecture is the art of creating a spatial environment for human life and society as a whole. An architect is a professional who creates various spaces (internal and external), thinking in terms of the geometric characteristics of the object being created for human life. The result of an architect's creative work is the design of buildings and structures. The main distinguishing feature of which are: enclosing structures, their geometry, which is the basis of the architectural appearance. Urban planners create relatively different spaces in which, due to their size, the vertical dimension is different in relation to the scale of the plans, and their work is often called territorial planning. The geometry of design becomes a dimension, starting from the numerical marks of the plans.

In the spaces created by architects, human life exists, forming its own development scenarios. Architects create residential projects. Internal light spaces flow into each other, forming a common living area (habitat) that requires a comfortable light environment for life [1].

Creating a comfortable light environment for people is an important task. How to define what this concept of «comfortable light environment» means for a particular person, what it includes, and how professionals should approach its creation? There are many opinions and definitions of this concept: from narrowly professional ones that exist in psychology and hygiene to global political ones expressed in government programs, plans and standards. There are many suggestions on how to approach the creation of a comfortable environment. This article considers the scenario of development of designing the light environment of spaces from personal to public.

Light is an indispensable and modern means of compositional shaping. Within the framework of the creative concept of an ecological approach to the formation of the human environment, the problem of using natural and artificial light in architecture comes to the fore.

Mastering the methods of rational organization of the light environment and increasing the expressiveness of buildings remains one of the most pressing tasks of modern architecture [2]. Building standards for lighting require significant clarification, as sunlight has light, heat, and radiation aspects, and this is extremely important in design.

Topical issues of optimizing architectural methods and means of designing the lighting environment are among the important problems noted in the recommendations of scientific seminars at research and educational institutions of architectural profile in Ukraine and abroad.

The aim of the study is to develop a general methodology for the study of a comfortable light environment in architectural design.

Research objectives: - to improve the methodological basis for the study of a complex of lighting means in architectural systems; - to identify a general methodology for the study of the "light component" in architecture.

The scientific novelty of the study is that for the first time: 1) the methodological basis for the study of the complex of lighting means in architectural systems has been improved; 2) a general methodology for the study of the light component in architectural systems has been identified.

**Main material and results.** Given the specific nature of the problem under study, the systemic and integrated approaches were chosen as the general strategy of the work. The methodological basis of this study can be the systemic approach as a direction focused on the study of: specific characteristics of complexly organized objects and the variety of connections between elements, their different qualities and subordination.

Cognition of an object as a system includes: determination of system elements; organization or system of connections; system properties; determination of possibilities of creation and trends of system changes. For an architectural object, the elements are localized (illuminated) spaces, the relations are their hierarchical subordination based on function, and the order of elements in these relations is their connections in accordance with the function [3].

*Personal space.* Everyone has a personal space. It implies a kind of personal zone of light comfort, where a person feels calm and confident. The personal area should be inaccessible to outsiders or have very limited access for them. Psychology determines the average physical size of a person's personal space. Intrusion into this space by strangers is perceived as «negative» [4].

Mikhailov I.B. defines the subject-spatial system and structure: «A system is a set of elements that are interconnected and create a certain holistic unity. The system consists of elements, structure and performs a certain function. Architectural elements are relatively indivisible parts of a whole object. Architectural structure is a stable and regular relationship between the elements of a system. Architectural function is an external manifestation of the properties of an object in a system of relations».

In the twenty-first century, a new idea of illumination and interior space has emerged, which forms the material world. Much in achieving a state of personal comfort and security depends on the level of education, the specifics of upbringing and the perception of the surrounding material components of the spatial environment - sounds, smells, text and artistic works reproduced with the help of technology and electronic devices. Today, entire industries have emerged that offer their services in creating the comfort of an individual personal space, and formulate proposals for creating a comfortable personal lifestyle.

In design, personal space can be viewed in a much broader sense than in psychology, with the main feature being individuality and the nature of personal use. Aesthetics, a set of functions and objects that make up the design concept of this space are the face of the customer (Fig. 1).

*Communicative space.* Personal communication space is a zone of personal comfort. In psychology, there is a physical concept of social space that extends from 1.2 to 3.6 meters. This is a zone of communication, which includes those with whom we have a private conversation, are comfortable in the presence of the interlocutor, or he is in the zone of our attention at the level of contact, communication [5]. A communication space that belongs not only to you.



Fig. 1. Antonello da Messina «St. Jerome in the Cell»; City Gallery: Antonello & the Architect [6]

Such a zone of communication space is private property. From the point of view of the law, this is one of the forms of property of an individual or legal entity or a group of individuals that the law is designed to protect. It has different types: individual, corporate, cooperative, joint stock, intellectual, copyright, and any other non-state form of property.

System structure is a description of a set of elements (system composition) and the most stable relationships between them. The systemic approach focuses the researcher on revealing the integrity of the object, on identifying various types of connections in it and bringing them together into a single theoretical picture [7].

Heron of Alexandria discovered that a ray of light passes between the eye and the light source along a shorter path. Later, physicist E. Fermi formulated the principle of light behavior: light chooses the path that requires the least time to travel from all possible paths connecting two points, because nothing happens in the world that does not make sense of some maximum or minimum.

The most understandable level of creating a comfortable environment is the living space, what we traditionally consider private space. A dwelling, apartment or private house is a space for living together and communicating with a close circle of people [8]. Environmental design has developed this part of the spaces created by architects in the most detailed way. The design of apartments and private houses is the field of work of a large number of professionals.

The private spaces of houses and apartments are being combined into villages, condominiums, and apartment buildings. These are communicative spaces of a more complex level. Participants can negotiate with each other through neighborliness [9]. They can be helped in this matter not only by the law, but also by a designer who can organize the life of a community of people in a professional manner, whose interests he can take into account during personal communication or communication with representatives to whom the customers have personally declared their rights and wishes. The main thing is direct contact and the possibility of personal discussion.

The second part of the communicative spaces is occupied by the objects of environmental design that are collectively owned or used by one relatively permanent or united by common interests group of people. From a legal point of view, collective ownership is a form of ownership of property by partnerships, cooperatives, associations and other cooperative, joint-stock and partnership organizations. Collectives of people united by common interests can be communities of residents of the same building, house or yard, owners and regular customers of a private enterprise, coffee shop, narrowly specialized store, beauty salon or sports club. Communicative spaces are the territories of housing and communal services and rural settlements. In the twenty-first century, the social media space emerged as the fourth dimension of the communication space. Social networks such as Twitter, Facebook, Myspace, Mixer, Sine Weibo, and many others create platforms for communication [10]. This sphere of communication relations is aimed not only at establishing personal contacts, but also at creating public opinion, shaping tastes and preferences, and conducting educational processes. Social networks support the programs of groups and societies,

and create communities that can begin the process of creating public space improvements. For example, the stories of the creation of New York's High Line and Low Line parks.

Public space. This refers to the internal space and the right to public property owned, managed and used by society, which is considered as a single entity. This is the most difficult level of work with light space to understand. Architects, sociology, economics, statistics, and many other social sciences study it. Society or society is extremely difficult to describe, but taking into account its interests is extremely important when working with public spaces [11]. For the improvement of residential and public spaces, the customer will be the human community, which is represented by relations, forms of interaction and association of different communities of people. Sociology describes models of social relations that act as a set of relationships between people. Society can be characterized, systematized, and divided according to many features: cultural, state, national, territorial, temporal, and even by means of production. In sociology, such a social division is described by the geological term for the arrangement of the earth's layers – «stratification».

G. Lavryk notes that the principle of compactness and the principle of defining features belong to the qualitative (metric) aspects of architectural theory. The principle of structure invariance is of a qualitative (relational) nature [12]. The researcher made an important conclusion: the relationship between the elements (subsystems) of integral architectural lighting objects is invariant for all objects.

Systems analysis is a scientific method of cognition, which is a sequence of actions to establish structural relationships between variables or elements of the system under study.

The task of designing the environment of public spaces is to create a comfortable light environment. Therefore, the issue of sociology and drawing up a social portrait of the intended users of light spaces is an extremely important task. It is important to understand: - how and on what grounds it is possible to unite people into social groups to work on the lighting of architectural objects; - how to distinguish these features; - how, based on the interests of the groups identified in accordance with the identified features, to form a comfortable lighting environment [13].

The task of architectural public spaces is to create opportunities for the formation of an open society. A comfortable light environment can only be created when a person feels personal freedom and equality of opportunity. For this purpose, conditions for the formation of internal spaces were created in architectural spaces by designing the material environment.

A new professional course called «Spatial design», which can be translated as «architectural design of residential and public spaces», is being introduced in educational institutions in the UK. As with any new field of knowledge, courses vary in scope and ambition from school to school. But it can be said that this new discipline, whose concept is still being developed, has already acquired a number of common, quite definite characteristics [14]. It is at the intersection of design, building architecture, landscape architecture, landscape and interior design, and public art. Its professional tasks focus on the connections that provide value in understanding the boundaries of the private and public spheres of people's lives. The emphasis in this new discipline is on research with people and space. Special attention is paid to creating a unique image of a place. Interior design covers different scales of perception: from detailed design of interior lighting to the design of development ideas for large regional strategies.

The analysis of the decision-making problem in the hierarchy analysis method begins with the construction of a hierarchical structure that includes three levels: Level I - the goal of choosing space lighting; Level II - criteria; Level III - alternatives and other lighting factors that are considered and that influence the choice of a solution. The top of the hierarchy is the main goal, the elements of the lower level represent a set of options for achieving alternatives, and the elements of the intermediate levels correspond to the criteria or factors that link the goal to the alternatives [15]. Building such a structure helps to analyze all aspects of the problem and delve deeper into the essence of the research task. Each element of the hierarchy can represent different aspects of the problem to be solved, and both tangible and intangible factors, quantitative parameters that are measured and qualitative characteristics, objective data and subjective expert opinions can be taken into account. The main task of the hierarchy is to evaluate higher levels based on the interaction of

different levels of the hierarchy, rather than direct dependence on the elements at these levels [16]. A hierarchical system is more stable and flexible - small changes have a small effect, and additions do not destroy the overall characteristics.

In theory, architectural systems are classified as «open» and «closed». A system is «closed» if it has no environment, i.e., no external systems that interact with it. Closed systems also include those systems that are not significantly affected by external systems. A system is called «open» if there are other systems connected to it. All living systems are «open» systems. Non-living systems are relatively «closed» [17]. The presence of feedback endows them with some incomplete properties of living systems related to the state of equilibrium.

Systems can be divided into «deterministic» and «timed» by their nature. In «deterministic» systems, the elements unambiguously interact in a precisely defined way. In such a system, the relationships between elements are unambiguously defined, deterministic, and therefore they are called «deterministic» systems [18]. For «deterministic» systems, the concept of integrity is important. In «terminated» systems, the connections between elements are random.

An architectural system is an open system because there are other systems connected to it (the environment, human society, and others) that influence it and are influenced by the system.

There are no unchanging systems; theoretically, in addition to dynamic systems, there are static systems that keep their parameters and relationships virtually unchanged over the entire time interval of interest to the researcher. Statistical systems are more often referred to as abstract or theoretical objects than real ones. For «open» systems, along with the concept of «internal» systems, the concept of «external» architectural environment is used, with which the system exchanges information, resources, substance, etc. Information itself becomes a system, begins to dominate lower-level systems, and «information begins to exist independently».

The following ensure the implementation of the principles of forming an ecologically balanced architectural environment: a systematic method of architectural and ecological approach, orientation design using internal or external lighting of the space, modeling, transformation, a set of energy and economic measures.

**Conclusions.** 1. The present study can be attributed to the modern profession of «Spatial design», or architectural design of a comfortable light environment. The principle of forming residential and public spaces of different formats is laid down. The principle of a strategy for sustainable development and the existence of indoor and outdoor space was developed. It was necessary to take into account the interests of selected groups of people, the possibilities for the development of architectural residential facilities, as well as the needs of such areas of public life as education, leisure, and ecology. To create comfortable interior and exterior spaces, the principle of maximum accessibility and the of creating conditions for the development of new social relations was taken into account. If we consider the architectural design of a comfortable light environment as a factor that connects the traditional design solution, then the light environment can become comfortable only when it creates conditions for the development of environment of people.

2. The methods of research and criteria for assessing the «light component» of architectural systems, as well as the methodology for studying the formative and comfortable function of light in architecture are considered.

3. The research methods are based on the demo-systemic and eco-systemic approaches, which are based on the interaction of a natural source with architecture. The concept of the study is based on the positive and negative impact of the natural source, as the main climatic factor, on humans and the environment.

4. The architectural system has the main components: 1 - the production sphere (production of technical products); 2 - the non-production sphere (service); 3 - the recreational sphere as a special type of activity and health improvement of the human body; 4 - the communication sphere (connections between these three components). The role of solar energy for each of these components is specific and requires separate case studies.

5. Various methods can be used in scientific research, such as monitoring, expert subjective assessments, analytical method, and structural modeling.

## References

- [1] Kristianova K., Jaszczak A. Historical Centers of Small Cities in Slovakia – Problems and Potentials of Creating Livable Public Spaces, IOP Conf.: Materials Science and Engineering (2020).
- [2] Wicaksono D., Pratiwi I., Wibowo A. A. Redesign Gajah Mungkur park in Semarang City as public space and green open space with using the concept “hidden layer of Semarang”. 10th Engineering International Conference. IOP Conf.: Earth and Environmental Science 969, (2022).
- [3] Yusofl Y.M., Kozlowski M. Public spaces and urban sustainability in the tropical built environment. IOP Conf. Series: Earth and Environmental Science 106, (2018).
- [4] Salleh M. Z. M., Othman N., Malek N. A., Mohamed N., Zainal M. H. Prospects of contemplative urban park from expert perspectives. IOP Conf. Series: Earth and Environmental Science 881, (2021).
- [5] What is a bike route? [Online]. Available: <https://www.oshawa.ca/en/transportation-parking/cycling.aspx> Accessed on: August 12, 2023.
- [6] Artchiv. St. Jerome in his cell. [Online]. Available: [https://arthive.com/uk/artists/453~Antonello\\_da\\_Messina/works/193501~Svjatoj\\_Ieronim\\_v\\_svoej\\_kel'e#show-work://246366](https://arthive.com/uk/artists/453~Antonello_da_Messina/works/193501~Svjatoj_Ieronim_v_svoej_kel'e#show-work://246366) Accessed on: August 12, 2023.
- [7] Rees Street Park. [Online]. Available: <http://blog.waterfrontoronto.ca/nbe/portal/wt/home/blog-home/posts/Lower-Yonge-Streets-and-Public-Realm> Accessed on: November 15, 2023.
- [8] A postcard from Vienna. [Online]. Available: <https://bicycledutch.wordpress.com/2017/08/22/a-postcard-from-vienna/> Accessed on: 22.08.2023.
- [9] Transportation Master Plan 2017 Update FINAL Prepared for the City of Post Falls, Idaho. Available: <https://www.postfalls.gov/PZDept/Engineering/EngProjects/TMPfinalMainDocument> Accessed on: December 24, 2023.
- [10] Kirkland, Washington, US. Available: <http://brtplan.com/our-services-2/brt-design/> Accessed on: November 10, 2023
- [11] Upcoming Changes – 12 ave cycle track. [Online]. Available: <https://bikecalgary.org/node/3848> Accessed on: August 22, 2023.
- [12] City of Los Angeles Mobility Plan 2035. Available: <https://planning.lacity.gov/eir/mobilityplan/FEIR/Addendum.pdf> Accessed on: June 15, 2023.
- [13] Koniuk A., Pavlikov A., Harkava O.. «Features of architectural and planning decisions of low-rise eco-buildings». AIP Conf. Proc. 15 February 2023.
- [14] Borodych L., Savchenko O., Koniuk A., Vasyliiev P. (2023). «Innovations in Architectural Design Based on Integrated Urban Development and Participative Planning». In: Onyshchenko, V., Mammadova, G., Sivitska, S., Gasimov, A. (eds) Proceedings of the 4th International Conference on Building Innovations. ICBI 2022. Lecture Notes in Civil Engineering, SCOPUS, vol. 299. Springer, Cham.
- [15] Koniuk A., Danko K., "Problemy arkhitekturnoi orhanizatsii ekolohichnoho ta enerhoefektyvnoho zhytla Na prykladi ekolohichnoho blokovanoho zhytlovoho budynku v m. Poltava", Enerhoefektyvnist v budivnytstvi ta arkhitekturi, SCOPUS, vol. 11, pp. 112-119, 2018.
- [16] Vasylenko O., Koniuk A., «Light facilities complex in architectural design», Book Chapter Lecture notes in civil engineering this link is disabled, SCOPUS, vol.73, pp. 491-499, 2020.
- [17] Koniuk A., Vasylenko O., Palii K., «Lighting means as factors influencing the formation of architectural environment», Lecture notes in civil engineering this link is disabled, SCOPUS, vol. 181, pp. 561-572, 2022.
- [18] Koniuk A., Vasylenko O., Vorobiova O. «Artificial Lighting Environment of the City», Conference Paper Artificial Lighting Environment of the City Lecture Notes in Civil Engineering, SCOPUS, vol. 299, pp. 585-596, 2023. <https://pragmatika.media/en/kak-zhiteljam-madrida-vernuli-mansanares-revitalizacia-proekt/> February 06, 2018.

## КОМФОРТНЕ СВІТЛОВЕ СЕРЕДОВИЩЕ В АРХІТЕКТУРНОМУ ПРОЕКТУВАННІ

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**Анотація.** У ХХІ столітті комфортне світлове середовище в архітектурі стає категорією, пов'язаною не лише з конкретним матеріальним простором. При проектуванні архітектурних об'єктів необхідно враховувати інтереси різних груп громадян, об'єднаних громадськими просторами. Створення комфортного середовища пов'язане з розумінням особистої свободи та проблемою створення умов для розвитку відкритого суспільства. Дане дослідження можна віднести до сучасної професії «Просторовий дизайн», або архітектурне проектування комфортного світлового середовища. Закладено принцип формування житлових і громадських просторів різного формату. Розроблено принцип стратегії сталого розвитку та існування внутрішнього і зовнішнього простору. У статті представлено основні принципи в галузі «дизайн середовища», окреслено методологічні засади дослідження комплексу засобів освітлення в архітектурних системах та детально описано загальну методика дослідження «світлової складової» архітектурних систем. Дослідження містить методи та критерії оцінки освітлення архітектурних систем та методика дослідження формотворчої та комфортної функцій світла в архітектурі. Світло має значний вплив на архітектуру будівель і споруд, формуючи належний рівень якості об'єкта, економічність рішень та художню виразність. Належний рівень освітлення в будівлях є важливою передумовою створення сприятливих умов для життєдіяльності людини, підвищення її творчої та продуктивної активності. Одним з основних факторів, що формують параметри світлового середовища, мікроклімату в приміщеннях та умови інсоляції, є законодавчі норми, представлені в Законах України: «Про охорону навколишнього природного середовища» 1991 року, «Про архітектурну діяльність» 2012 року. Актуальність теми даної роботи обумовлена необхідністю удосконалення науково обґрунтованої методичної бази дослідження з урахуванням сучасних засобів освітлення.

**Ключові слова:** комфортне світлове середовище, архітектурний простір, природне і штучне освітлення, комплекс світлових засобів, методика дослідження, критерії оцінки, внутрішній простір, архітектурне світлове середовище.