Light factor in the city’s architectural environment

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Abstract. Lighting design is the area regulated today only indirectly, proceeding from requirements of visibility of objects, mainly, criteria of quantity of light on road coverings and facades of the lit objects and uneven distribution on them. There is an underestimation of its role and potential in creating an artistic image of the city in the design of its architectural environment, counting on the visual perception of it only in the daytime. Purpose of research. To identify and formulate problems and prospects for the development of lighting design, to develop recommendations for the light solution of the urban environment. To consider the light environment as a system, to determine the main levels of architectural and compositional tasks of its formation. Method of research. With the help of the analysis of the light environment of the city of Belgorod the problems of its formation are revealed. The main disadvantage of the formation of the urban light environment is the lack of unity in the solution of lighting different areas of the city, the prevalence of light advertising over architectural objects, destroying the stylistic unity of the urban environment. The comparison of the solution of such problems by the Metropolitan administration is carried out. The importance of light as a factor in the formation of the originality of the city is noted. Research result. The development of the concept of urban lighting is proposed, its basic principles are highlighted, ways of solving the problem of organizing night lighting of the urban environment are identified. The potential of lighting design and lighting technologies in modern architecture is only half, and in Russian projects – hardly a quarter. We are in the beginning, but a growing number of interesting projects gives reason to believe that we are moving in the right direction and with the right approach, using the expertise already available, by purchasing and accumulating your own will inevitably achieve the development of their professional achievements in the field of lighting design and the organization of the light environment of the city. Currently, the problem of competent and qualified approach to urban lighting requires the full attention of architects-urban planners and architectural and design organizations.

Introduction
The parameters of any light space in the city today are regulated only indirectly, based on the requirements of the objects’ visibility, mainly by the criteria for the amount of light on pavements and facades of illuminated objects and the unevenness of its distribution to them. In the theory of urban planning and architecture, there is still no clearly defined problem of forming an artificial light
environment of a city as a professional and relatively autonomous creative task, as an independent division of any architectural project, and there is no methodology for its solution. Outdoor lighting is included in the section of the urban areas engineering equipment [1]. Therefore, there is often an underestimation of its role and potential in creating the artistic image of the city when designing its architectural environment, while relying on its visual perception only in the daytime. Despite this, spectacular projects and embodiments of night lighting of architectural environment objects always attract interest in new opportunities for improving form and space, as well as in technical innovations in the world of lighting design.

There are three main problems in the development of lighting urban architectural environment:

The problem of lack of qualified professionals. To date, there are no graduates in Russia with the wording of a light designer. Education is developed in the field of architecture, design of the architectural environment, or architectural physics. These professions suggest the possibility to be engaged in the lighting design, there are also specialists who are technically capable of solving the problem of the city lighting, but it is necessary to train personnel whose qualifications will allow them to master the full range of skills of the lighting designer. Many scientific papers were devoted to this problem, there is foreign experience, the objective and urgent need to master the art of lighting is no longer an exotic, unimportant, engineering task, but as one of the many-sided and promising architectural problems that should be solved in the process of a city designing, its fragments and most of its objects [2].

The first problem, by itself, implies the following problem, which has a common beginning with the problems of architects and the city planners - the problem of coordination at the administrative level. As we have already found out, there are not enough qualified specialists in this field; accordingly, they are not in the structures authorized to coordinate projects and issue permission for their implementation. Often, people who decide the “fate” of a project have their own opinion and vision of the situation, not always based on the scientific knowledge in this area, but on their own intuitive understanding by virtue of their intellectual abilities. And even from a professional point of view, a project does not go through the procedure of administrative coordination due to this circumstance and is forcibly subjected to corrections leading to irreversible mistakes and the destruction of the originally harmonious solution.

Even if one succeeds in preserving the idea of a project for lighting a city object, there remains an open question of a conscientious approach to project implementation by the customer, sometimes wishing to save on materials, and the question of the conscientious performance of their work by the constructors and technicians who want to save their time and effort. Then an image completely unrecognizable, having only a distant resemblance to the project appears. Here we should not forget about the peculiarities of the visual light perception. The human eye is designed so that in reality it can distort the object of vision, and even if an object is made exactly with the project, the designers themselves see differences that they could not take into account in the design process.

Such researchers as L. N. Avdotin, M. G. Barkhin, A. V. Bunin, A. P. Vergunov, V. L. Glazychev, A. E. Gutnov, A. V. Ikonnikov, L. I. Kirillov, I. V. Kosytsky, A. Kuchmar, IG Lezhava, K. Lynch, I. M. Smolyar, 3. N. Yargina, I.V. Migalina, E.N. Sokolov, L.N. Mironov Itten, G. Frieling, K. Auer, S.S. Alekseev, V.A. Zernov, G.Tsoigner, M. Deribere, D. Judd, G. Vyshetski and others discussed this problem. They managed to identify some problems of the medium light originality formation, noting the importance of lighting as a factor in the formation of the identity of the city [3]. There is practically no mention of the evening environment and the light image of the night city as architectural-compositional problems deserving professional attention, and visual assessment of the urban environment under artificial lighting is also not made. Today, the most striking and complete research of this field is the scientific works of Nikolay Shchepetkov, the Head of the Department of Architectural Physics at the Moscow Institute of Architecture, professor, doctor of architecture, laureate of the State Prize of the Russian Federation, corresponding member of the Russian Academy of Natural Sciences, member of the Union of Architects and the Union of Designers of Moscow and his followers.

Russian and foreign practice of using the main types of night lighting.
Artificial light interacts with the architectural form in its four main types and categories: space, volume, plastic and color. The nature of the light has an important influence on all categories of the architectural form. It is necessary to take into account the intensity of light, the brightness of the reflections, the depth of the shadows, the material and the color [4].

The two main components of the light environment — the space “filled” with light (light space) and the lighted objects (light forms) have not yet been “composite” today in their lighting indicators due to the lack of methodology and criteria for their photometric compatibility.

Initially, the formation of light space is based on a number of factors characteristic of the formation of the compositional environment of the city as a whole. The only difference is that during the day many more factors influence the architectural environment of the city than its formation at night, when the main influence on it is made by light. Without artificial light we will not see anything – only a “black square” with a clear sky, there may be some silhouettes or general outlines, but they absolutely will not give us any idea about the space around us. Only with the advent of sources of artificial lighting in our minds is the image of the city formed. Each source of light in the dark is a kind of “magic wand” that can give a space a surprisingly intimate, cozy sound, snatch a fragment of a building from the darkness, a section of the square, creating a center of gravity literally from scratch, where there are no architectural and urban planning prerequisites [5]. When designing lighting, it is necessary to take into account the interconnection of buildings and structures with the space of streets, intersections and squares. If the light is not applied correctly, one can completely distort the existing objects and spaces, disrupt the orientation and comfort of a person, even if during the day the urban environment is perfectly formed.

Comfort is a major factor in the system for assessing the quality of the living environment. Comfortable living environment should satisfy aesthetic, psycho-physiological, ergonomic needs and peculiarities of a person. In conditions of poor visibility, it is possible to define only a dark, comfortable environment, it means familiar, familiar, unchanged with the arrival of the night, only played with new colors and accents. Thus, the task of the lighting designer is to maintain the existing architectural image of the building, the street, the urban space, while maintaining compositional integrity and emphasizing the necessary visual features.

![Figure 1. a - lighting in the day image, b - "counter image".](image)

When organizing the lighting of an architectural form, there are two fundamentally different directions. Lighting is formed in the image of daylight. This method is relevant for the light decorative organization of architectural monuments, history, culture and monumental art when the image has no associative analogs with a different architectural form. The second way of organizing the lighting is a decorative-theatrical “counter image”. This lighting option has its own expressive qualities and has no direct visual counterparts in daylight. Both methods should be harmoniously combined and, if necessary, maintain the effect of each other [6].

The stationary light sources prevailing in any city are installations of general functional illumination of road and, in part, lawn coverings in traffic and pedestrian areas. They should ensure that certain areas of urban areas can be used in the evening and at night. They “fill” the urban environment with light,
forming utilitarian light spaces and simultaneously participating in the integrated optical formation of architectural light spaces. Their participation can be conventionally called passive-background [7]. But it cannot be considered separately with outdoor architectural lighting (facades of buildings, structures, trees) and light information and advertising, which serves as the main informative element of the environment creating image characteristics and actively participate in the optical formation of architectural light spaces.

To create the correct light composition of the urban environment, a competent combination of lighting options for streets, buildings and urban spaces with the filling of their individual elements with functional lighting is necessary. It is important to prevent discord in the relationship of function and necessity with architectural expressiveness and revealing the form of urban space.

**Analysis of the lighting design technical possibilities development strategies**

Today, in Belgorod, mainly advertising agencies which are interested in developing lighting only for individual objects, with which customers they directly deal with are engaged in lighting design. Trying to organize their actions and create harmony between different buildings in the image and principle of illumination, in order to reveal the light space as a whole, the city administration developed and approved a color lighting scheme distinguishing the city streets according to different colors of night lighting. But it turned out to be more difficult to implement the designers’ ideas. It is impossible to highlight the hospital in red or the orange sign in yellow, this will create visual discomfort or incorrect associations. The determination of the color of night illumination is influenced by many factors that already exist: the purpose of the building, its geometric shape, its color in daylight, the landscape, the climatic features of the region, etc. These factors will be necessary to implement into the proposed scheme. But letting advertising agencies dictate their conditions to the detriment of the overall integrity and harmony of the light environment is impossible. Synthesis is needed: a more loyal approach on the part of matching structures and a professional approach to lighting designers. It is necessary to take into account the interests of designers, without disturbing the harmony of space. The perception of the night image of the city by its residents and guests should be relied on. What points the pedestrians, cyclists and motorists most often look at the city where their main routes run, whether the existing lighting causes discomfort or provides a sense of security — all these factors should be considered when developing the concept of lighting the urban space. The results of the analysis of the urban space will show what needs to be preserved, what needs to be improved or completely changed in the available light scheme. The authors of the future concept of lighting get an idea of how the city is perceived by people living in it and visiting tourists, what is of great importance.

The lighting specificity of an artificial light environment is clearly detected when comparing it with the daylight. The light field is characterized by a low general level of illumination (or light saturation) in the presence of sources with excessive brightness, high contrast and irregularity of illumination, diverse direction of light fluxes with different intensity and chromaticity of radiation, complex shadow formation and elemental dynamics. The distribution of brightness - a decisive factor in visual perception [8]. The sky is almost always almost the darkest element of the visible environment, often occupying most of the visual field and determining the adaptive mode of the eye. Instead of dominating the afternoon positive silhouette frames with negative contrast (dark objects against a bright sky background), the evening lighting creates negative positive contrasts (bright objects against a dark background). Multi-spectral light enhances the heterogeneity of the light environment, and in cases of monochromatic radiation from sources with poor color reproduction, for example, widely used sodium lamps, on the contrary, it visually homogenizes it.

The decree was issued on the mandatory development of architectural lighting for all objects under construction and reconstruction in the central part of the city and in the historical areas of the city, as well as for city-forming objects. Typically, such projects are approved by the artistic council, whose decision should be based on various regulatory documents. Resolution No. 44 of the State Committee for Construction of Russia dated May 29, 2003 approved CNaR 23-05-95 * “Natural and artificial lighting”, which included an additional subsection on outdoor architectural lighting of buildings and
structures. Clause 7.56 requires the outdoor night lighting to “provide in the evening good visibility and expressiveness of the most important objects with an increase in the comfort of the city’s light environment.” Lighting devices and installations “should not produce a blinding effect on drivers of transport and pedestrians.” Paragraph 7.60 provides recommendations on the ratio of the maximum and minimum illumination within the same zone: “not less than 10: 1 and not more than 30: 1 on an element accentuated by light” [9]. Also formulated recommendations on the choice of light sources, for example, energy-saving lamps, and the rules prohibiting illumination (direct rays from external lighting devices) windows of residential or working premises. But one problem remains unresolved - modern science cannot yet determine the single and most important parameter for rationing, since the mechanisms of the reaction of the human eye and nervous system to light are not completely clear. It is determined only that the wrong light mode significantly affects fatigue and psycho-emotional state of a person. There is even the concept of light noise, in which there are many unnecessarily bright light sources of different quality in the visible zone. This is usually due to the large number and variety of light advertising [3].

There are three main principles, which should underlie the concept of the urban space lighting:

- durability, durability, reproducibility and self-sufficiency. The use of this parameter in creating lighting projects is very characteristic of the European and American lighting design of the last decade. A lighting solution with this property eliminates any redundancy. It should be restrained, delicate in relation to the urban environment and its unique features.

- The structural nature of the plan. All elements of urban space are divided into several groups and for each of them a solution is created. Individual approach can be applied to individual objects within each group, depending on their location and functional purpose.

- integral approach. It is designed to balance the diversity of individual lighting solutions, to put them together, to get a solid, harmonious light appearance of the city in the dark, to balance the combination of general lighting and detailed light processing of individual objects and zones. Such an approach can be achieved by using decorative park lamps harmoniously combined with the forms of steel lighting poles, as well as modular lighting poles and lamps with architectural solutions of buildings and structures [6].

When working on the lighting of the urban structure, special attention is paid to the facades. The solution for night lighting of the building has three layers. The first layer is functional light. It is provided by spotlights, mounted on the facades at a height of 9 to 12 m. The second layer is artistic lighting of architectural details. The compact upward-facing lamps, built into the facade above the ground floor where the stores are located, are responsible for it. The lighting inside the shops should harmoniously complement the facade lighting. In this regard, the lighting of shop windows should be turned off only together with the facade. The third light layer is an individual illumination of historical monuments located on shopping streets and squares [10]. Under the condition of an active stream of people, we combine the most safely and effectively on decorative lighting poles of the OSS, OS, OSK type with lighting lanterns and architectural illuminators, placing them between the lamps on special brackets [2].

The reserve, which remains after calculating the energy consumption of all major life support systems and security is usually considered for the street lighting. (This question is highly relevant: in many cities there is a shortage of electricity, rolling blackouts and so on are practiced) [11]. If lighting designers are invited to the stage of full project readiness, or even the construction of an object, the cost of implementing any concept of architectural lighting grows noticeably, often at times. In addition, many interesting solutions become simply impossible to implement. For example, when working on a curtain wall, it is necessary to install additional fasteners designed for the weight of devices, which can exceed 3 kg.

In the modern world, thanks to the development of new technologies, the range of possibilities for illuminating architectural forms has expanded considerably, and the technical means have become much more complicated. New types of incandescent lamps, various types of gas-discharge light sources with and without the use of luminescence, lighting devices of complex design appeared and introduced. Lighting control technology has expanded its capabilities. The use of light devices using digital control has changed the perception of the light-decorative organization of the architectural environment. At this
stage, there are several types of lighting organization: - general flood lighting, including dynamic lighting; - local and zone lighting; - light facades; - background or silhouette lighting; - contour lighting; - dynamic lighting; - Projecting graphics on the facades [12]. The use of various types of lighting will allow to solve certain tasks: the achievement of artistic and decorative effects; ensuring the stylistic unity of the environment of the city; the creation of a variety of illusions (visual increase in the height of the object, relief of its mass, segmentation, etc.); the formation of dynamic illumination; highlighting the most spectacular architectural details; enhancing the aesthetic characteristics of an object, creating a new character of its perception; enhancing the security of the object, its environment and transport and pedestrian communications.

Figure 2. Night illumination of the city of Belgorod from different specific points

With increasing rates of the technical capabilities improvement, it is necessary to improve and develop the concept of lighting the urban space of the city of Belgorod. It is necessary to solve the global tasks of forming the light environment of the city: create an individual artistic image of the city, identify its individual architectural and plastic structure in the night light, determine the sequence of the selection of historical ensembles on the background of the rest of the lighting, streamline advertising, form orientation systems in urban space, create an emphasis on certain specific points of the city, to identify the natural and anthropogenic landscape of the city. The harmony of the lighting solution will be achieved with the logic of expedient unification in constructions of constructive and artistic properties, as well as their interaction with various types and types of lighting [13].

Summary
The solution of the city night lighting, as well as architectural, engineering, transport and other issues, is one of the main elements of the formation of the urban planning ensemble and has a significant psychological impact on city residents. Architectural lighting design is an amazing phenomenon, at the junction of art and high technology, with its own magic, capable of transforming an ordinary urban landscape into something enchanting, festive, magical [14]. But we have to admit that the potential of lighting design and lighting technologies in modern architecture is only half revealed, while in Russian projects it is barely a quarter. We are at the beginning of the path, but an increasing number of interesting projects gives the reason to believe that we are moving from darkness to light. We still have everything ahead, both in the creative field and in terms of the technologies used. The practice of urban lighting follows the development of lighting engineering, using it and depending on it, but it does not efficiently form an order for the type of product that is required to form the necessary, including aesthetic qualities of the light environment for which, responsible architects and town planners. Partly, therefore, a number of technical innovations that had certain advantages over others did not receive further use in illuminating the city; others did not go beyond experimental or exotic means often used in the avant-garde areas of synthetic arts working with light (light and music, rock, light shows and performances “Sound and Light”, etc., or in light advertising, although they have been known for several decades
(LEDs, electroluminescent panels, holograms, light guides, light projections, light optodynamic lighting, laser light-transmission, “artificial Moons”, etc.) [15].

A professional solution requires the development of programs for the development of the lighting design of the architectural environment of the Belgorod city and its phased design in the system of architectural and urban planning. The involvement of qualified and experienced specialists in this field, as well as the training and education of our own staff, will lead to an increase in the professional level of lighting design.

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