Light Spaces and Forms in the City Light Planning Structure

V E Karpenko

1Department of Architectural Environment and Interior Design, School of Engineering, Far Eastern Federal University (FEFU), 8 Sukhanova St. Vladivostok 690091, Russia
2Department of Architectural and Design, Technical Institute (School), Far Eastern Federal University (FEFU), 8 Sukhanova St. Vladivostok 690091, Russia

E-mail: vekarpenko@gmail.com

Abstract. Artificial light is an effective and modern means of designing an urban environment, including architectural forms and spaces. Various functions and lighting concepts suggest the identification of the lighting nature of urban elements in the planning structure. Artistic and light parameters of forms and spaces can be measured using psychological and artistic compositional methods. Artificial light as part of the composition is used in optical and modern visual art, emphasizing its importance in landscape design, in revealing the semiotics of the city, in light landscapes formation. The analysis of artistic-psychological and comparatively estimated quantitative data of light forms and light spaces can be taken into account when creating a harmonious architectural and light environment. The theory of the city light-planning structure, lighting spaces and forms is given, the methods of their lighting on the embankments, in the historical part of the city are described, the mechanisms of their psychological impact and the measurement of subjective perception are revealed. The light-spatial parameters and lighting criteria are described. Variants and perspective proposals are put forward for creating light spaces based on the sum of the expressed light plastic of facades and the volumetric-spatial composition of buildings, landscape, light spaces as the intersection of communications and the harmonious interaction of light forms in the structure of the historic city centre. The reliability of the study can be provided by the earlier used "semantic differential" method.

1. Introduction: relevance and development of a scientific problem

Artificial light is a modern tool for urban planning, the creation of light spaces and light forms. A variety of light objects (media facades, installations, illuminated facades, light sculptures) in the city general structure form the architectural and light space of the city. The concepts of light spaces and light forms have been developed, their types, compositional laws and principles of their formation have been proposed in the theory and practice of light design. [1]

Many urban changes and city reconstructions were initiated with the aim of streamlining traffic in growing cities for pedestrians and vehicles, convenient access to various spaces, sights, mainly by the shortest distance and clear path. [2] The formation of city light ensembles may also accompany urban development. Artificial light reveals visual corridors and connections, guides city traffic for tourists and residents. When using artistic lighting in various cities, it was noticed that, for example, the planning structure was revealed with the help of light in Vienna, the spatial structure of the main architectural ensembles was expressed in Paris, the socio-political and business centers of the city...
stood out in Washington, and artificial light was designed in Rome as guide to the city historical center [1, 3]. As a result, the light-planning structure includes light landmarks, dominants and accents that act as “beacons” and landmarks. A pedestrian striving to go from dark to light, or in a light-saturated environment, does not perceive the surrounding dark environment, and a visual field is limited. These psychophysiological mechanisms of visual adaptation are important principles for the design of movement in a nightly urban environment [1]. The question of assessing light forms and spaces arises from the point of urban planning and aesthetic significance view.

Many urban planning, psychological and evaluative-comparative methods in the field of art can be applied to study the light environment of cities. The method of graphic elements formal analysis uses binary oppositions or pairs that describe the art form using the statistical method of “semantic differential”. [4-7] The architectural and light environment contains light spaces and light forms, which can be structured into smaller light elements, this sum of light forms designed or arising in a certain order or formed spontaneously form a complex light environment. An artistic appraisal of such a light structure can also be determined by one of the means of architectural composition, which is the rhythm or a variety of its variants. [8]

The formation of certain psychological reactions in response to the presentation of an art-expressive light form can be found in various types of visual art, in the era of avant-garde and modernism, when the use of artificial light as a compositional technique can be seen in performances, installations, projections, etc. The light is an active part of the composition in op-art. The modern practice of using artificial light as an artistic element is largely based on the experience of the avant-garde in general and the first projection-light plays at the Bauhaus Week exhibitions in 1920. [9-12]

From the point of view of the light planning of cities, fundamental theoretical and practical questions have already been developed, scientific directions and guidelines have been proposed and given that still require the setting of additional experiments, clarification of problems in the architectural and lighting environment [1]. The orientation of city streets, neighborhoods and squares, buildings or facades determine their external daytime appearance. Some facades are never directly illuminated by sunlight or only receive reflected light, others are exposed to the sun during the day, and natural sunlight creates a special atmosphere of light in every city. At the same time, artificial lighting doesn’t depend on natural daytime insolance, which allows to create new lighting effects taking into account the reflection or color change of the facade material. Artificial light is a tool for creating a second cityscape that interacts with the city view at sunrise and sunset. [13] The concept of “light codes” of cities is to interpret the light environment as a system of semiotic signs that can be encoded and decoded, and the resulting “light code” plays a key role in the perception of the city socially, culturally and economically [14]. The semiotics of the urban environment is studied and the emphasis is placed on the values of the “rootedness of urban places in history” and the preservation of objective evidence of urban spaces [15, p. 200]. Landscape lighting is due to many complex factors, such as plant growth and development, season, weather conditions, perception, open exterior space. LED sources and their electronic control systems, electrical engineering are also of great practical importance in landscape lighting. [16] The role of natural and artificial lighting as a catalyst and a stimulus for perceiving the aesthetics and diversity of natural landscapes visible from cities is considered. [16, 17]

2. Research problem statement
The formation of the city’s light-planning structure, including light spaces and light forms and based on the laws of art-expressive and urban planning composition, forms harmonious and comfortable light spaces of embankments, squares and other public spaces of the city, contributes to the formation of a general positive psychoemotional and social climate. At the same time, light forms and light spaces can streamline the city’s light environment, make up light ensembles and dominants that can serve as landmarks, direct pedestrian traffic, and improve the quality of light-volumetric parameters of city light spaces. This article proposes variable solutions for the formation of light spaces and light forms. The prospect of further research is expressed in the use of psychological methods, full-scale
lighting measurements in the city's light space. Field empirical and statistical evaluative and comparative studies can be used to identify aesthetic, stressful and psychological factors in the perception of light spaces and light forms in the city light environment.

3. Light categories of architectural form and space in the city light-planning structure

3.1. Theory of the city light planning structure
The light-planning structure of the city is based on the urban-planning differentiation of its space and consists of a “light-planning framework” and “light-planning fabric”, includes a system of light dominants, ensembles and accents, which, in accordance with the city-planning position, receive the corresponding light-color design by various light-composition techniques revealed by artificial light of a certain spectral mixture, brightness, amount of light, its kinetics in installations of functional, architectural and navigation lighting, and a light ensemble is the main structural unit. The city’s “light-planning framework” includes a characteristic sinuous pattern of transport highways, which with the help of utilitarian lighting can be differentiated by meaning - roads inside the quarter, residential area, large highways and is determined by the visibility parameters for drivers at high speeds at night. Transport nodes are identified. Local and decorative lighting emphasizes the coastline and creates an attractive night environment of the embankments. In public centers, a comfortable lighting environment is formed for communication, recreation and movement, the light spaces of which are determined by the nature of behavior and the speed of a person movement. Hence, different light parameters of the environment, depending on the conditions of visual perception and visual connections, the nature of people's behavior, urban planning structure. The comfortable and chamber lighting is used in the spaces of rest. The spaces of movement (sidewalks) are parallel to the roads, but the lighting in them is scale to humans. Communication spaces, as the most important planning elements of the city, can be distinguished by a neutral-white light, high levels of illumination, special light-compositional techniques, a system of light signs and visual communications. Residential territory is the filling of the city “light-planning fabric”: lighting of the house adjoining territories both in the city historical center and in new residential areas. In industrial areas, light dominants can be high-rise engineering structures and functional lighting has been created. Lighting reveals the historical center and the peripheral zone of mass development. [1]

3.2. Theory of light forms and light spaces
The interaction of artificial light with the architectural form creates four specific architectural categories and light form: light space, light forms, light plastic and light colour with new visual parameters. In terms of function, urban light spaces are divided into transport and pedestrian. According to the nature of human moving, pedestrian spaces are usually divided into spaces of rest, communication and movement. Ensuring the visibility and visibility of objects is especially important in pedestrian spaces. One of the main functions of artificial light in urban street spaces is primarily to provide functional or utilitarian lighting. The aesthetic qualities of the light environment are ensured by the architectural and artistic lighting of buildings, structures, trees, landscape, small architectural forms in all the variety of their plastic expression and colour. The illuminated facades of buildings and structures create light forms with their light plastic and light colour. Primary lightsources form elementary light spaces, the shape of which is determined by the photometric body of this lightsources in the kind of optical cones, spheres, cylinders, taking into account the degree of transparency of urban air. Light spaces are also formed by reflected light – secondary emitters. Integration of elementary light spaces creates a complex light space in the structure of a linear street, square or other urban elements. In this case, it is desirable to ensure the continuity of the light-optical field within a one light space. In general, an artificial light environment includes many light spaces formed by luminous elements and reflecting the surfaces of objects and earth illuminated by them. The lighting scale created by different types of lighting devices defines microspaces, mesospaces and macrospaces. The
rhythmic arrangement of local light sources on the building facade, corresponding to the plastics and tectonics of the building, will emphasize the integrity of the light form image. [1]

3.3. Receptions of architectural and artistic lighting of the central historical environment urban planning elements: light expression of embankments and public spaces

The system of light-compositional means in modeling architectural and artistic lighting of the embankments developed in the course of project modeling made it possible to formulate some light-compositional techniques. The creation of new lighting techniques is also based on the symbols of the coastal city and images of the sea. Identified and proposed images are observed when illuminating coastal structures. The components of the embankments environmental forms during modeling contain: light-transmitting parts and small perforation of coating materials and fencing. Lighting effects emphasize the mating details and overhanging structures of supports, piers and parapets above the water, reveal the spherical and conical shape of small architectural forms. Light shows, monitors and media facades, art objects, landscape lighting, trees, flowerbeds enliven the coastal light space. The light gradient simulates the effect of waves, water, sails. Of great functional importance is dividing and signal lighting at the border of the pier and the water. Modern energy-saving technologies are used in lighting embankments - LED light sources and wind generators are used. The lighting plan of the embankments is expressed in the color temperature difference of the horizontal lighting, the height of the lamps, in the contour of the lamps built in the paving, light navigation, the rhythm of the placed lamps, in the lighting of bicycle and pedestrian communications. Lighting landscapes can “outline” the light space of embankments, enhance the visual and optical effects of depth and planarity, and emphasize the light silhouette, rhythm and localization of many light forms.

When modeling the transport and pedestrian light spaces of the historical cities centers, the horizontal pattern of lighting in pedestrian and transport light spaces can be taken into account. Modeling the facade light plastic is to reveal the architectural style, coloristic of a building or structure, identify facade plastic, emphasize architectural details (domes, risalits, towers, arches, etc.), using polychrome light and media facades. Urban spaces of streets, squares and other public territories saturated with light forms are integrated into urban structures and form linear street, coastal or local light spaces. [18, 19]

4. Psychology of the perception of the city light spaces and lights forms

4.1. The psychological impact of light spaces and light forms in the urban environment

The light environment can be considered as a system consisting of light-colored and other stimulus. The psychological impact of the light environment is the initial visual processing of the light form. In the architectural and lighting environment, there is a sharp and uneven distribution of brightness contrasts in the view field and the phenomena of positive or negative visual induction - an increase or a decrease in the effect of a direct irritant (blindness, discomfort, veiling shroud), which influence and determine the formation of stressful states and situations. In this case, a person may experience visual and psychological fatigue.

The light environment as an integration of light spaces, light forms, light plastic and light colors represents a complex psychological set of visual-psychological stimulus. In a modern urban environment, each stimulus (light shape or light space) has brightness and color, especially if LED light sources are used, and color light is an effective artistic and expressive means. In this case, the color (polychromatic component of the light) as a characteristic of the lightsource enhances the effect of the architectural and light environment. The change of dark and light spaces causes a process of visual adaptation, which is characterized by psychophysiological reactions and can lead to temporary psychological discomfort or prolonged stress in a person. In addition, in modern urban space there is an excess of sensory information, which leads to overloads of the visual and nervous system. The high pace of urban life is also accompanied by other psychological problems: uncertainty and anxiety, which also leads to stress. [20] Monotonous homogeneous visual fields are one of the problems of an
uncomfortable daytime urban environment. The monotony or dynamics of light rhythms consisting of traffic lights or randomly glowing windows of residential buildings (during the day these are homogeneous visual fields, and in the evening there is a chaotic glow of windows), or the light forms of illuminated architectural objects and structures can also cause a negative psychological effect. [21, 22]

4.2. Psychological measurements of subjective perception of light form and light space
The artistic and structural characteristics of the light form and light space can be emotionally evaluated using binary opposition, i.e. using the method of “semantic differential”(SD) proposed by the American psychologist C. Osgood, then analyzed statistically and mathematically. This method was used in architectural psychology. First of all, the light structure can be defined as the “eye-pleasing” form with its inherent artistic and compositional properties, the identification of which will allow to model the aesthetic parameters of the light saturation and expressiveness of light form and light space. SD is a bipolar or unipolar graduated scale, which can include both evaluative and substantive features. The most significant signs of light spaces and light forms lie in the field of light saturation, which affects the visual perception and aesthetics of these light structures. With the help of SD, you can evaluate the emotional reaction and the property of the object itself - light space or light form. Discrepancies between the images of light-space or the light form laid down during modeling and the images perceived by the viewer can be determined with SD. An indirect characteristic of light-space or light-form is what impression it causes the viewer. [6, 21]

4.3. Light-spatial lighting parameters
When assessing the quantitative and qualitative parameters of artificial lighting in urban light spaces, several photometric indicators are taken into account. Light distribution on the road surface, facades, surfaces and face of a person is determined by the indicators of horizontal and vertical illuminance (Eh, Eh). The criterion of light saturation and light distribution at the level of a person’s face is described by semi-cylindrical and hemispherical illumination (Esc, Esb). Criteria for shadowing, which characterize the contrast of lighting on the pedestrian’s face and are indicators of the light-modeling effect, the uniformity of lighting on the road surfaces, respectively, are expressed by the following relationships: E/h/E, Eh/Eh, Eh/Eh. [1, 18, 23, 24]

5. Conclusions: the practical significance and prospects of the study
5.1. Some conceptual proposals for the formation of a light environment
When lighting can be accented, the light forms that forming certain light spaces and having city-planning significance in the light ensemble - in the transport and pedestrian space – are intersection of streets and sidewalks, corners of notable objects, risalits, domes, etc. The choice of various illuminance, brightness, color temperature in light spaces can be carried out depending on the main function of the city urban space. Modeling and forecasting of light dominants at the panorama level involves the transition to a detailed definition of light forms at the level of central streets light ensembles, for which their own lighting scenarios are determined, reflecting the symbolic and semantic role of urban elements.

When forming the light environment of night streets, sensors can be used that take into account the movements of pedestrians, cars, the sound of streets, etc. The collected digital data programs lighting scenarios at the level of light panoramas. When designing pedestrian lighting spaces of streets and embankments, squares, parks and green "pockets", it is necessary to take into account horizontal and vertical illuminance, the light-volume parameters of the environment at the level of a person’s face, and the lighting ratios that create the light-spatial characteristics of the city and form the necessary visual and psycho-emotional atmosphere of the environment. In the city light space, it is necessary to create new landscape light dominants on the relief, to illuminate the natural elements: slopes, hills, rocks, mountains, embankments, water surfaces of bays and reservoirs.
5.2. Practical results of improving the psychological atmosphere in the city light environment

The device of temporary light installations within the framework of cultural projects improves and increases the light-spatial indicators, the light-modeling effect of fragments of the architectural and cities lighting environment. The formation of light installations contributes to the psychological and visual comfort of the light environment of pedestrian spaces. The history of the urban area allows you to create a unique lighting project and express the "spirit of the place." With the help of light, you can identify and emphasize the space urban composition. [18, 25, 26]. The lack of quantitative and qualitative photometric measured indicators of the night environment allows us to offer light-space and light-composition corrections in the pedestrian streets space in accordance with the street layout, the existing arrangement of lamps, elements of improvement, light advertising and architectural lighting. [24]

5.3. The reliability of the results

Reliability can be ensured using the proven statistical method of “semantic differential” (SD) in identifying the subjective perception of existing light spaces and light forms, with a compositional and psychological assessment of the visual environment and the shape of city illuminated ensembles, including light dominants, accents and background. Previously, the SD method was used in the analysis of the shape of the city’s light panorama, in assessing the color of urban buildings, the modern urban environment and courtyards, the emotional state in the urban environment, and in the study of historical and central urban spaces in the daytime and at night. The method allows you to identify the subjective attitude of respondents according to several compositional, psychological and urban planning criteria and aspects of the light panorama. The data obtained make it possible to formulate further ways of adjusting the object of study, for example, to create light-compositional techniques and principles of stage space in the formation of a light panorama of the city. [6, 27, 28]

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