The study of urban factors in the human comfort system

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Abstract. The modern format of people's livelihoods is characterized by pronounced trends toward concentration in large settlements. These processes relate to the processes and technologies of urbanism. One of the key human problems in urbanism is the problem of comfort. The authors developed the structure of the formation of signs of human comfort by environmental factors, structure of human interaction with the physical components of the environment under urbanism. Studies show that the thermal load on a person increases in areas of urban space, where the surfaces of structures have a high density. The authors developed the system for generating thermal comfort for design of architectural objects in high temperature. Heat loss by convection requires external air movement. The article presents new scheme the surface microstructure of small local objects (for the facade decoration, objects of restrictive structures, window decorations and additional design objects of the urban environment). Additional layers of materials include heat-storing components. The development of a variety of design solutions based on the proposed concept will allow us to solve the problems of not only comfort in urbanism, but also to form new directions in the range of functional building materials and architectural objects.

1. Introduction

The modern format of people's livelihoods is characterized by pronounced trends toward concentration in large settlements [1]. Studies and statistics show that over the next few years, the share of the world's inhabitants concentrated in megacities will be 75% [2]. This vector of development leads to the formation of a high population density with complex infrastructure and life support technologies in limited space areas [3]. These processes relate to the processes and technologies of urbanism [4]. The traditional characteristics of urbanism are the rapid growth of the urban population, the concentration of the population mainly in large cities and the expansion of urban areas [5]. Vital activities in the system of combining the labor and everyday spheres of a person’s life under urbanism have a number of serious problems. One of the key human problems in urbanism is the problem of comfort [6]. Human comfort is a complex and multifactorial concept [7]. Many studies are devoted to the comfort and effectiveness of human life. Aspects of comfort relate to physiological and psychological comfort. A significant degree of ensuring human comfort in the metropolis is the immediate environment [8]. Figure1 shows the structure of the formation of signs of human comfort by environmental factors (developed by the authors).
2. Relevance and Scientific Merit of the Problem. Formulation of the problem
An analysis of the developed structure showed that thermal comfort is a component of both physiological and psychological comfort, and therefore is of particular interest [9]. Based on the criteria of human thermal comfort, it is advisable to develop criteria and a basic concept for the design of the environmental spaces of human life in urban conditions.

In modern urban studies, much attention is paid to the environmental safety of the urban environment, which is based on a general environmental assessment of the modern city. Ensuring environmental safety includes an analysis of the environmental hygiene parameters, an ecological and integrated assessment of the urban environment, as well as an analysis of natural and anthropogenic factors [10]. The processes of urban planning, analytics and forecasting are associated with the use of special calculations aimed at taking into account demographic, socio-economic, environmental, territorial and other factors affecting the development of the urban environment. The problem of modern large cities is exacerbated by a sharp lack of natural and spatial resources. Designing the territories of cities with concentrated infrastructure leads to the layering of the functions of construction and other engineering objects on a limited area. The mutual intersection of various physical environmental factors in the human stay area leads to complex systems of interaction between biological objects and engineering spaces. Figure 2 shows the developed structure of human interaction with the physical components of the environment under urbanism (developed by the authors).

With a significant role of a number of physical factors in the city’s ecology, such as dust, radiation of various nature, noise and vibration, the chemical composition of air and light, a significant contribution to the overall perception of comfort in the above conditions is made by the temperature of the environment [4, 11]. A number of authors consider the issues of thermal signs of the environment for human life in the city [12], noting the conditions of the heating environment as a high physiological load, leading to dangerous conditions and pathological discomfort of a person [8]. Studies show that the thermal load on a person increases in areas of urban space, where the surfaces of structures have a high density, and the surfaces of materials for a long time retain the high temperature received from a natural heat source [13]. Such aggregate heat transfer aimed at the continuous heating of all surfaces of urban infrastructure objects (road surface, architectural objects, open-type engineering communications, transport objects and material surfaces on people themselves) leads to a critical overheating of a person, not only with the loss of all comfort components, but also risks to life and loss of labor efficiency and general disability.

Therefore, the study of the conditions of the heat load on a person in an urban area and a heating climate is not only relevant, but also requires the development of a concept and technical solutions for
the design of environmental spaces and the design of local structures to increase human comfort in high-temperature urban environments.

![Figure 2. The Structure of human interaction the physical components of the environment under urbanism.](image)

### 3. Theoretical part

The design-system can be represented as a unique system, the rational interaction of the components of which ensures its smooth functioning. Figure 3 shows the system for generating thermal comfort for design of architectural objects in high temperature (the authors developed).

![Figure 3. The surface structure of small local objects.](image)

An important condition for a person’s well-being, preservation of his high working capacity and health is the provision of temperature homeostasis (i.e. thermostable state) of the body [14]. So, a violation of temperature homeostasis is a consequence of a violation of the heat balance, which leads to tension of the mechanisms of thermoregulation and can have a significant effect on the state of various functional systems of a person (cardiovascular, nervous, respiratory, endocrine, etc.). A certain share in maintaining the heat balance, of course, belongs to physiological thermoregulation. However, at an ambient temperature of 35 °C or more, the ability of human thermoregulation [8,15], aimed at maintaining thermal balance is very limited. During intense physical work, when the air heated to 37 °C and above, heat transfer occurs due to sweating [16]. The choice of principle can be confirmed by analyzing the heat balance equation [8,17]:

\[ Q_1 + Q_2 = Q_3 + Q_4 + Q_5 + Q_6 + Q_7 + Q_8 + Q_9 \pm Q_{10}, \]  

(1)

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where \( Q_1 \) - human heat production;

\( Q_2 \) – external heat load (solar radiation);

\( Q_3 \) – heat loss by radiation;

\( Q_4 \) – convection heat loss;

\( Q_5 \) – conduction heat loss;

\( Q_6 \) – heat loss by evaporation of diffusion moisture from the skin surface;

\( Q_7 \) – heat loss by evaporation from the upper respiratory tract;

\( Q_8 \) – heat loss by evaporation of sweat;

\( Q_9 \) – heat loss due to heating of the inhaled air;

\( Q_{10} \) – deficiency or accumulation of heat in the body.

Having analyzed the given equation of heat balance, certain corrections should be made taking into account the peculiarities of human physiology during mining and rescue operations. The left side of the equation, consisting of the sum of heat accumulations from the heat production of a person and the influence of external heat load, represents a significant amount of heat, which is concentrated in the human body and becomes a direct prerequisite for overheating of a person.

If we consider the right side of equation (1), it should be noted that heat loss by radiation under given conditions is practically not feasible, since the temperature of the fences surrounding the person is higher than the temperature of the body surface. The conditions of heat loss by conduction are reduced to the necessity of contacting the surface of the human body with surfaces whose temperature is much lower than the temperature of the body, which, depending on the objects of environmental design, is almost impossible to implement in the natural conditions of the city. Heat loss by evaporation of diffusion moisture from the skin surface makes up a small fraction of a person’s heat-regulating ability, since the surrounding air is saturated with moisture that exceeds standard data. Due to the loss of heat from the upper respiratory tract, there is no decrease in the heat content of the body, since the surrounding air has a high temperature. Heat loss by convection requires external air movement. And in combination with the humidity mode, which allows controlling the thermal conductivity of the layer of materials included in the human heat transfer system in the environment \[18\], convective heat transfer means are of great importance.

4. Results of experimental research
An analysis of the presented system for the formation of the human heat balance made it possible to develop a design concept for urban environment objects, including surfaces.

In Figure 4 presents the surface microstructure of small local objects (1) - facade decoration, objects of restrictive structures, window decorations and additional design objects of the urban environment. The formation of increased convection and, thereby, the activation of the heat-removing effect from the surface of the human skin of excess heat occurs through the interaction of a person with air flows of greater speed, which has a vortex character. Additional layers of materials include heat-storing components (2). Structure of materials for the surface design of urban objects based on the proposed concept is presented in Figure 3.

Microstructural studies were conducted for modern materials \[19\]. Material options are selected for local surfaces of architectural objects \[20\]. They have a useful surface for stimulating eddy air flows \[21\]. These surface properties can help increase ventilation in small spaces. This is an important result for improving human comfort at small distances between structures and objects of object design in the city.

5. Conclusion
The formation of increased convection and, thereby, the activation of the heat-removing effect from the surface of the human of excess heat occurs through the interaction of a person with air flows of
greater speed, which has a vortex character. Additional layers of materials include heat-storing components.

![Figure 4. The surface microstructure of small local objects (1-surface structure, 2-inclusion of thermal storage, 3-basic material of construction.](image)

The developed concept and design solutions of the elements of the facade and decorative structures of urban spaces in the areas of movement of people flows in a warm climate forms the activation of an important component in ensuring the thermal comfort of a person. This component is the convective and conductive removal of excess heat.

The development of a variety of design solutions based on the proposed concept will allow us to solve the problems of not only comfort in urbanism, but also to form new directions in the range of functional building materials and architectural objects.

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