The Organization of Natural Lighting in Buildings with Difficult Illuminated Areas

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Abstract. In conditions of rower crisis the questions of resource saving have gained special urgency in all spheres. Modern problems in the sphere of effective energy use are versatile and they start to influence architectural and building decisions more and more. A wide range of questions concerns providing buildings with natural illumination as artificial illumination together with central heating charges have got leading positions. They make more than a half of operational charges of a building. The most effective decision is to supply buildings with natural illumination but it is often connected with a few problems because it is important to remember about thermal stability of constructions.

It is known that a building loses less heat as it grows in width. It becomes more resistible to different climatic influences. But as the width of a building grows some hardly illuminated parts of buildings appear. It is possible to supply organizations with sunlight in remote parts of buildings regarding decrease of resource consumption (changing traditional approaches to building illumination with natural light). In the following article the generalization of variants of organization of natural illumination of hardly lighted areas is made. All the positive and negative sides are concerned.

1. Introduction

The questions of effective power resource consumption have recently aroused heated debates worldwide. This topic is actively discussed in Russia finding development in state programmes of different levels. The wide use of natural illumination is a way of great economy creating a comfortable environment for people who are in a building. Artificial illumination takes the most charges in the building sphere while they can be potentially much lower [1, 2]. The sunlight is necessary to provide the required characteristics of microclimate inside a building, it has a favourable psychophysical influence on a person, solves aesthetic and utilitarian tasks (provides the duration of insolation and normative indicator of an area illumination) [3, 4]. There are some types of natural illumination: side, upper and combined one. The use of a particular type in buildings and constructions depends on a large number of outer and inner factors. They are: natural and climatic conditions, outer context of a landscape (a countryside or a city), architectural surroundings, the regime of building exploitation and many more [5, 6]. Providing buildings with natural light is a very important criterion of effective resource expense as there is a direct connection between the coefficient of the front part glazing and building heat loss. Technical heat characteristics of a building are very important concerning the questions of power effectiveness [7]. The more windows of bigger size there are in a building, which
provide natural light, the more is the heat loss. The heat loss is directly connected with proportions of constructions. It is possible to reduce the heat loss due to the increase of width of a building. The wider a building is, the less heat it loses [8, 9]. While designing constructions with a wide housing, architects face problems of providing hardly lighted remote parts of buildings with illumination. They have to solve problems of effective resource usage on central heating or conditioning. In most cases as a result of architectural decisions for construction planning, charges on artificial illumination grow. Thus, it is necessary to consider systems which will let review the questions of power saving in complex and offer variants of hardly lighted areas illumination with natural light taking into account improved indicators of power effectiveness for the whole construction.

2. Materials and methods

Materials of a few articles and dissertations are used for generalization of materials dealing with questions of organization of natural illumination of remote parts of a building. Modern approaches to the realization of these questions considering the analysis of the Russian experience as well as the experience of designing and building from abroad have been studied. Special attention has been paid to studying and comparing of modern devices, their effectiveness which let us solve the problem of sunlight providing of remote parts of buildings on a highly technological contemporary scale.

3. Results

Let us examine some variants of organization of sunlight illumination of remote parts of buildings. It is hardly possible to obtain the required depth of the sunlight penetration into the construction using side illumination. Deep penetration of the light would require big window openings that would increase the heat loss of an object. That would be ineffective from the point of view of resource saving. Thus, the most effective way to illuminate the remote parts of a building would be to apply combined (side and upper) or upper illumination. The most widespread type of upper illumination is a lantern. Lanterns are used for illumination of public and industrial buildings rather often [10, 11]. There are a lot of types of lanterns different in shape and design but they are always placed on roofs, having therefore their advantages and disadvantages. The possibility of providing buildings or their areas with natural light can be considered as an advantage. In such areas there is no opportunity to supply the so-called “hardly lighted” areas with side illumination [12, 13]. The disadvantages are the decrease of aerodynamic characteristics of buildings, the increase of snow pressure because of “snow bags”, the leakage of the housetop in places of joint with a lantern, the decrease of lantern effectiveness when the sun is low, especially in winter [3, 14].

Atrium can also be regarded as one of the architectural ways of illumination organization of remote parts with natural light. There is a wide range of types of atriums and their division according to classification signs, but while designing in most cases they are directly headed at solving tasks of natural illumination. They act as architectural and composite emphasis. An “ideal” atrium, it goes without saying, takes part in distribution of natural illumination in the structure of a building. It implies the system of upper illumination providing maximum of light transmission. Side walls reflect the sunlight which spreads downstairs providing “hardly lighted” areas with natural illumination. If a building is designed competently and the shape of atrium is chosen correctly as well as reflecting materials, the sunlight spreads as in a light guide going further on different levels. We can call the following scheme rational: the sufficient amount of natural light gets on each level, the other part of it spreads on lower floors.

When all the climatic features of the place of construction are properly considered, atrium acts as an active element in the programme of power saving. It takes part in providing a quality microclimate in a building which can be called its positive side [15].

Opaque covers and items. Different products and constructions made of glass and glass-fibre plastic can treated as such. Architectural items including translucent constructions usually differ with originality and figurativeness. It is interesting how these constructions are used in the dimension of a building and in recreation areas. Constructions serve to illuminate buildings and underground areas
with natural light during the daytime. At night it is an element of surrounding backlight, it is an object of artificial lighting (light goes from inside to the outside) [16]. The necessity of usage of a large area of transparent covers for providing required illumination of a placement can be considered as a negative side. It decreases the power effectiveness of a building.

When the area of a building is large but the number of floors is small, “lighting wells” are a good way of illumination. This technology appeared at the end of the previous century and has become rather popular with its development. The main advantage of this technology is its power effectiveness. Another one is that it can be installed on the roof as well as on the façade of a building. It can also provide a building with light independently of the position of a construction itself [17]. The power effectiveness can be explained by the construction of the device: a little area of glazing leads to little heat loss. Thus, this device lowers the workload on many engineering systems providing a high level of resource saving and absolute ecological compatibility.

The device consists of a collector (the receiving element), a tube (the conducting element) and a diffuser. A great advantage of this system is the usage of moving mirrors in the structure of the collector. They are oriented to the sun and are constantly turning according to it. The light is gathered by the collector during the daytime that lets illuminate the placement with natural light from dawn till dusk. The light can dissipate or gather into beams inside the tube due to mirror lenses. It can also change the direction and spectrum due to the inclusion of definite technical devices. It provides the evenness of illumination, a high quality of colour rendition and lack of stream pulsation. A source of artificial illumination can also be included in the structure of this device. It strengthens the daylight or compensates its disadvantage totally on a cloudy day or at night [18, 19].

This system has several disadvantages. Firstly, it has a complex optical system in its structure which costs a lot. Secondly, the device can be applied only in placements where there is no need of a person’s visual contact with the environment. Another essential disadvantage is that it is necessary to provide a building with a definite space for the photoconductive tube. That influences the structure of the object taking into account its planning, engineering and technical sides. This kind of technology is widely spread abroad but its use in Russia is rather limited [10, 20, 22].

Hybrid systems of natural illumination. This technology is quite popular “on the market” and suits buildings of different functional purposes.

The system is identical to the “lighting well” and is intended to the sunlight directing and improving the quality of natural illumination in a placement. Solar cell panels and storage batteries are included in its structure optionally which provide collection and accumulation of solar energy for its usage on cloudy days or at night. The electricity consumption in buildings provided with such hybrid systems lowers to75% [21]. The great advantage of this system is its independent work and usage of ecologically clean renewable power sources. The use of such systems would be very attractive from the point of view of resource saving while exploitation of the objects.

Illumination with solar reflector arrays. This system can be partly compared with a “lighting well” but at a larger scale. The typical kind of system consists of receiving concentrating device of solar reflector arrays. Being in the environment it receives and redirects light to the “mirror wall”. From this the light goes either to inner spaces or to the hardly lighted places through the lighting mines. It depends upon the type of light transformation (single-stage or two-stage). Heliostats can be placed either on the roof of the building or the neighbour ones. They can also be situated on the ground level. The usage of such systems can save 40-70% of power energy which is spent on illumination. S great advantage of this system is that it is able to work autonomically and is easily integrated with systems of artificial illumination. Thus, the use of intellectual devices which let use the advantages of the combined type of illumination (natural and artificial) is urgent.

The cost of the system, the difficulty of installation and the unhandiness of the equipment can be called its disadvantages. The number of heliostats usually corresponds to the number of illuminated spaces and they demand large areas for placing. Besides, while using the lighting mines in the illumination of the building this system gains all the disadvantages which are characteristic of devices of “lighting well” type.
4. Discussion
The research has let not only reveal the possibility of providing the remote parts of the building with natural light but it has also indicated some definite problems. The disadvantages defined the way of further development of technical devices which will let escape some negative moments characteristic of existing appliances. Scientifically the research also supposes different directions for further investigations in this sphere.

5. Conclusions
The analysis of advantages and disadvantages of the organization of illumination of remote parts of buildings with natural light let select the most suitable variant of light distribution I the structure of a building. The research done by the authors proved the effectiveness of “green” technologies which are able not only to improve the quality and evenness of natural illumination of all parts of the building but to shorten (considerably) the power charges in the process of object exploitation.

The choice of the natural illumination in the building should be done by refusing from the stereotypes in designing. It is a difficult and complex task as providing of a high quality of natural illumination and comfort in a building and the maximum of power effectiveness of proposed decisions.

For optimal illumination and comfort in a building considering all the factors, an individual approach is necessary in each case taking into account all the macroclimate created in dwellings.

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