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The Role of the Solar Light Quantity in the Architectural Forming of Buildings

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Abstract

The influence of solar energy to the architecture of buildings is undeniable. From the seventies of the twentieth century, lots of terms and definitions appeared, trying to describe a style of architecture based on the principles of taking into account the climatic conditions and the exploitation of the potential of local energy resources such as solar energy.
Theory of Architecture usually focuses on the mutual relation between building constructions and architectural forms. But, in the process of architectural forms design, the elements that are not directly related to the structural base of the building, are included too. Sustainable ways of heating, ventilation, water supply and so on, directly or indirectly affect the architectural planning. One of the important factors that affect the shape of the building is the elements associated with the solar energy.
Issues of how to Influence of solar energy on the architectural shaping of buildings are described in this article.

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Keywords: architecture, solar energy, passive solar building design, solar heating.

1. Introduction

The term “passive solar building design” was created not so far. On practice it means the control of the heat flows by the means of architectural formation. Architectural formation is based on the rules of appearance of the heat flows and movement. Nowadays, an architectural shape has no direct relation to a structure as close as it used to be

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before. Methods and means of energy efficiency advanced and became a considerable shaping factor.

The influence of the elements of solar systems to the architecture of buildings is undeniable. From the seventies of the twentieth century, lots of terms and definitions appeared, trying to describe a style of architecture based on the principles of taking into account the climatic conditions and the exploitation of the potential of local energy resources such as solar energy.

This is the very first serious approach to the architecture, as a science, indicating a significant impact of the overall ecological stability, in connection with ubiquitous knowledge of the necessity for environmental protection, reduction of technogenic and anthropogenic pressure on the biosphere. The energy crisis of the twentieth century brought a certain contribution in the form of a new architectural style, as well as the desire to achieve energy independence for countries which lost their reserves of traditional energy resources.

The history of architecture, in a certain sense, is the process of aesthetic conquest of new technical means, used in civil engineering, "Conversion of utility to elegance", in the words of A. K. Krasovsky. Theory of Architecture usually focuses on the mutual relation between building constructions and architectural forms. But, in the process of architectural forms design, the elements that are not directly related to the structural base of the building, are included too. Sustainable ways of heating, ventilation, water supply and so on, directly or indirectly affect the architectural planning. In other words, the whole gamut of technical means used in the construction industry, in one way or another affect the process of the forms' design in architecture.

The progress of contemporary architecture consists not only of the implementation of innovative constructions solutions, but also the implementation of the latest facility for the objects support, which in turn affect forms' design. One of the important factors that affect the shape of the modern building is the elements associated with the use of solar energy.

Analysis of the current experience of energy efficient modernization of buildings, monuments of history and culture, based on solar energy has shown the existence of principally different approaches.

2. The Influence of sunlight on the architectural shaping of buildings

Humankind always considered and used natural local resources in the long run of history. Unique local features of buildings and structures were formed due to this reason. Historical examples of structures designed to protect buildings from heating are broadly known, as well as methods used to improve thermal properties of conventional dwellings in Northern lands.[1]

Prevailing winds and incoming solar radiation were considered in city planning and buildings construction. Consider a few examples.

Acoma Pueblo is a settlement built by American Indians in the 12 th century A.D. which isstill

inhabited. Acoma Pueblo has rows of three-level, apartment-style buildings which face south. The roof for one level would serve as the floor for another (Fig. 1). Settlement was designed to make maximum use of solar energy in the winter period and to minimize solar heating of buildings during the summer period [2].

Fig. 1. Acoma Pueblo

There are two ‘street networks’ in Los Angeles (USA) up to now (Fig. 2). One street network is implemented in accordance with the ‘Land Development act’, 1785 (streets go in separate directions «east – west» and «north – south»), and the second one is a kind of an old Spanish network. This cross-street Spanish network of the 16th century was designed with due account for sea winds directions. Street directions were not occasional ones and ensured an optimal insolation for buildings.

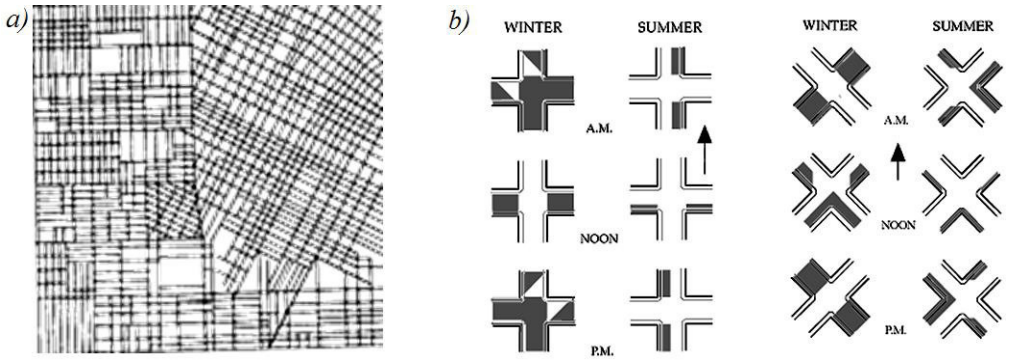

Fig. 2. a) Streets directions in Los-Angeles; b) Street shadepatterns A so-called ‘street shade pattern’ is of interest (Fig. 2 b).

When it comes to the quality of street space arrangement an ‘American’ grid leaves to be much desired. Streets are in shortage of insolation in winter time, and in excess of solar radiation in summer. This affects the value of commercial objects in cities especially in downtowns and commercial areas. In winter time each ‘Spanish grid’ street receives direct sunlight from 9 a.m. to 3 p.m. At noon all the streets have their shades but their cross arrangement ensures more insolation than an arrangement ‘east – west’.

With glass coming in everyday life new challenges for solar heating appeared.

The property of sun beams to heat internal spaces of rooms considerably going through glass was described by a Swiss natural scientist Horace Bénédicte de Saussure in 1770 [2]. And the first practical use of this property was construction of green and orchard houses to grow exotic plants. Construction of orchards was widely spread in the 19th century. The Palm House in the Royal Botanic Gardens Edinburgh (1834) can serve as an example.

An architectural shape of orchards created for solar energy use turned into architectural design of civil buildings.

It should be noted that an author of the prominent The Crystal Palace was an expert in orchards’ construction, an engineer Sir Joseph Paxton (Fig. 3 a)).

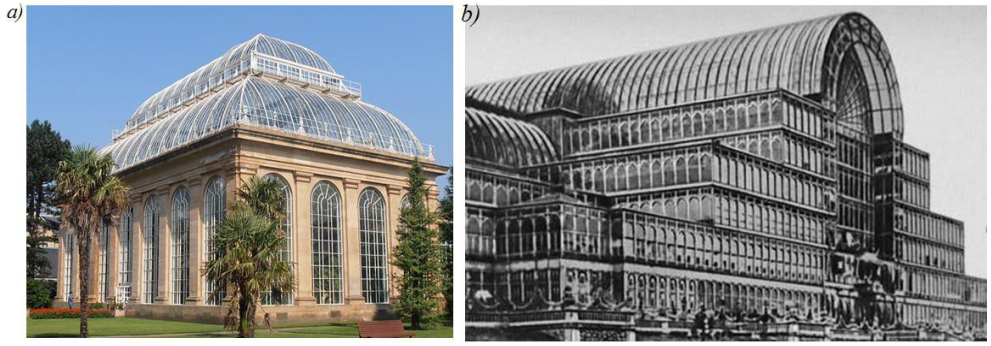

Fig. 3. a) The Palm House in the Royal Botanic Gardens; b) The Crystal Palace

Such a building extension as an orchard was in fashion in the 19th century. Ideas and concepts how to make landscapes and gardens harmonized with architecture were expressed in the works of such landscape designers as Humphry Repton (Fig. 6,a)).

A winter garden or an orchard was added to a building in the area of dining room or a library form the South side. In sunny winter days doors between a winter garden and a house were usually open to let the air heated by the sun in and circulate in the room. At nights doors were closed (Fig. 4). By the end of 1800s winter gardens added to buildings appeared to be an important architectural element for noble mansions.

Fig. 4. An integrated winter garden as an important architectural element of a noble mansion[1]

3. Passive solar building design

A notion ‘passive solar building design’ has been arisen so far. In fact, it means heat flows management using architectural shaping. Architectural shaping is based on logic of heat flows generation and movement. To development of "solar buildings" is devoted a lot of scientific researches. [3-8]

Passive thermal solar systems use an approach of a heat-carrier agent through this system due to its natural gravity produced by the difference between densities of a heated and a cooled carrier. Supplementary devices (a pump, for instance) are used to transfer a heat-carrier agent in *active thermal solar systems*.

In fact, any object made of glass added to a building from the South side (south-west, south-east) can serve as a passive thermal solar system. Energy gains generated by an extended glass building (winter garden or an additional room of practical use) are hot high. Thermal insulated structures (2- 3 double glass units and thermally insulated profiles) are used to avoid over-heating in summer and over-cooling in winter.

Solar radiation and, consequently, heat flows in a building can be managed by a target-oriented movement of translucent and non-transparent building elements. Solid structure units are used to accumulate thermal energy. Interaction between an object made of glass and a main building can be implemented under the following schemes (Fig. 5) [10]:

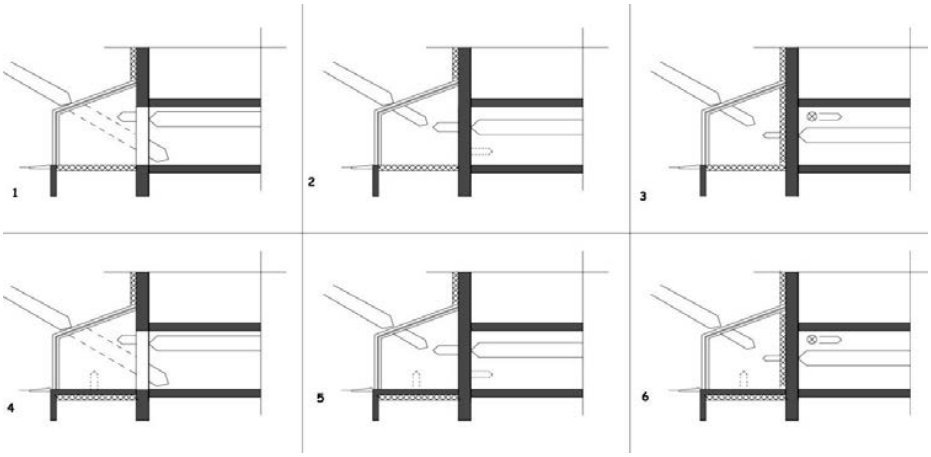

Fig. 5. Schemes of interaction between an added object made of glass and a mainbuilding.

Scheme 1-3: due to thermal insulation of the floor higher temperatures and a fast heating can be achieved.

Scheme 4-6: the thermally-insulated floor can be a heat accumulator and it can make an added object made of glass balanced in terms of thermal insulation

Scheme 1, 4: an added object and a main building have visual and thermal relations.

Scheme 2, 5: thermal relation: a building wall is used as a heating accumulator, and an added object made of glass can change a part of external thermal insulation.

Scheme 3, 6: thermal 'isolation': heat income can be achieved only due to forced blowing.

The basic principles Passive Design is based upon climate considerations to control heating and cooling without consuming fuels, uses the orientation of the building to control heat gain and heat loss, uses of free solar energy for heating and lighting, (Fig. 6, b)) [11]. Window placement and glazing type are very important factors [12-16].

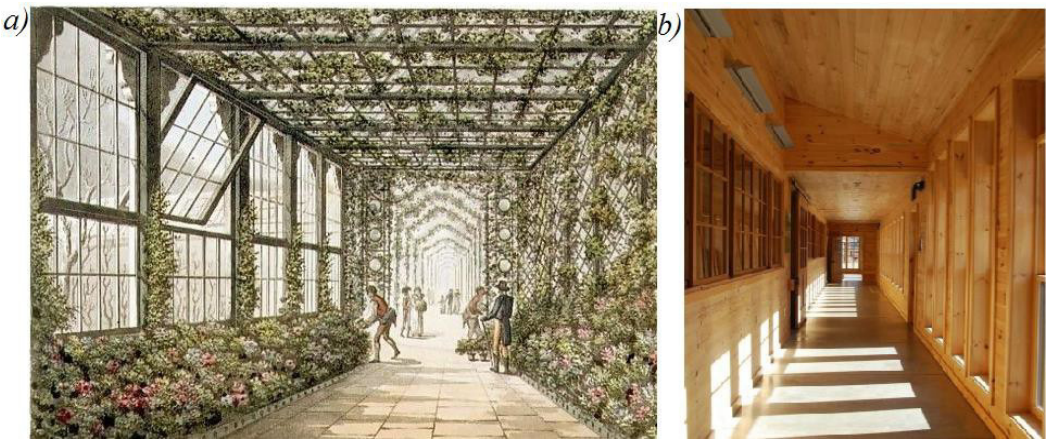

Fig. 6. a) 'Corridor' Pavilion project in Briton. Humphry Repton, 1802; b) Gallery, anelement of modern Passive Design

Constructions had minor affects on architectural shapes so far. There are the grounds to believe these are energy supply means that will affect architectural design of buildings. Energy supply methods and means became a significant forming factor.

4. Conclusions

Almost unlimited and enormous amount of energy and materials appeared in building and construction industry in the last mid-century brought to the situation when potential of existing local energy resources was neglected to a significant extent. Today we can observe that basics of energy production and consumption in all human activities are still under revision.

It may be stated that a new architectural ideology of the 21st century, which is focused on efficient energy resources consumption, is currently being developed. Ways and means of energy supply step forward and become a significant forming factor.

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