INVESTIGATE THE NATURAL LIGHT IN ARCHITECTURAL DESIGNING BY REDUCING ENERGY CONSUMPTION' APPROACH

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ABSTRACT
The use of daylight in architecture not only meets mental and physical needs of human, but also reduces the fossil energy consumption. From this perspective, Iran’s rich architecture has valuable achievements and experience that requires recognition and introduction to the architecture community of Iran and the world. Although Iran is among the richest country in terms of energy resources, improper use and waste of them imposes irreparable damage to the country's annual budget as far as the construction sector, by using over 40 % of the total energy produced in the country and 30 % of the proceeds from sale of oil, has the highest level of energy consumption. Since electricity has the greatest share of energy consumption in buildings, providing new ways to reduce energy consumption is necessary. In the meantime, the use of natural light in spaces plays an effective role in energy efficiency and prevention from electricity dissipation, because usual solutions in the present era, i.e. the use of electric lighting systems, cause heating the space and physical damage (eye) in addition to their high cost. In this paper, we account the benefits of using natural light in buildings, and then explain how to use natural light in architecture. At the end, we will present and describe new ways to use this natural resource.

Keywords: Architecture, natural light, reduce energy consumption.

INTRODUCTION
Iran, with more than seven thousand years’ history of urbanization and highly diverse geographical and topography status, is one of the treasures in the world’s architectural history. Climate diversity on the one hand and a long history of settlement, on the other hand, caused this territory to have interesting and valuable achievements in the field of Architecture and Urban Development; including the daylighting practices in buildings and urban spaces. Solar energy is one of free and clean sources of energy free from adverse environmental impacts that has been traditionally used by mankind in various methods. The energy crisis in recent years has made the world's countries to treat the issues relating to energy in a different manner. In the meantime, replacing fossil fuels with renewable energy, including solar energy, to reduce and save energy consumption, control supply and demand for energy and reduce pollutant emissions has been greatly welcomed [1]. The use of solar energy in buildings is one of the oldest applications of this type of energy, but what has drawn the most attention in this regard is the use of solar thermal energy on which there are many research and too many findings. In Iran, the direct use of sunlight for lighting has received less attention, while new and efficient methods have been invented in this regard with the progress of science and technology, and this paper is going to describe these methods. In the art of building or architecture, light is an element proposed along with other elements and concepts such as spatial order structure, materials, color and etc. and has to play its role in design as a separate element. But the fact is that in many interior architecture and construction cases, light is seen mainly as a lighting factor that would reduce artificial light consumption and thereby reduce the power consumption. However, natural light should be involved in lighting a building considering the prevention from attracting undesirable heat.

THE NECESSITY OF RESEARCH

Modern architecture in Iran is completely dependent on the use of artificial light, especially in housing, education and administrative sectors where there is an urgent need to provide light. In practice, the use of natural light that is the most reasonable, cost-effective and clear type of light has been buried. With regard to the existing problems in the area of fossil energy supply as well as environmental problems caused by indiscriminate use of this type of energy, it is essential to reconsider the traditional ways of construction and the use of advanced natural lighting systems.

LITERATURE REVIEW

Throughout history, daylight and building design has been always of interest to architects due to benefiting from this natural gift. Since power and lamp has invented and allowed the illumination of the interior space artificially, the use of natural daylight was often neglected. The last 100-year experience showed that the physical and psychological need of human to daylight is deeper than lighting by electric power; so the studies related to daylight and its optimal use has drawn special attention in developed countries of the world for many years. In this regard, international communities such as the Commission of Illumination in Europe (CIE), Illuminating Engineering Society of North America (IESNA), China Illuminating Engineering Society (CIES), India Lighting Society (ILSE), and other scientific research communities in Australia and Canada are responsible for doing research and production of lighting standards, both natural and artificial light. Given the expansion of scientific knowledge in the country during recent years and the interest of some students to carry out research projects in the field of natural lighting in architecture, some research has been done theoretically on the daylight calculation daylight and some field study has been conducted in connection with natural lighting conditions in office and education spaces; including the research by Tahbaz (2004), Sanaati (2006), Faizmand (2011), Kazemzadeh (2011) and etc. [2]. The establishment of Iranian Association of Lighting and Illumination Engineering was another positive measure in this regard. The necessity of using daylight in architecture, on the one hand, and software development, on the other hand, provided facilities to decrypt the causes of success or failure of lighting in various spaces. By the advent of this knowledge in Iran, in a new direction has been made to study daylight in historical places.

THE BENEFITS OF USING NATURAL LIGHT IN ARCHITECTURE

The use of natural light has many benefits and advantages. Here, there are some of main advantages of this divine gift in brief:

1. Reduction of energy consumption: less dependence on artificial lighting can reduce the use of electricity up to 10%.

2. Reduction of microbial agents and fungi in buildings: most of diseases, especially chronic respiratory problems, are often related to bacterial agents and fungi formed in wet places of the building such as cellars and bathrooms. Natural light can naturally reduce the formation of harmful organisms and sunlight is considered as one of the best disinfectants.

3. Improved health due to vitamin D: plenty of sunlight can prevent from the lack of vitamins D and B1 that may cause diseases such as rickets and beriberi [3].

4. Improve efficiency due to changes in the workplace: A lot of case studies have concluded that performance of personnel working at the places with natural light has been significantly improved.
5. Increased visual attractions in interior design: natural light is still one of the best lighting systems used in interior design, while successful combination of light with structure or building can be a challenging and satisfactory job.

6. Daylight is one of the primary factors creating natural rhythm in biological systems due to ultraviolet rays.

7. The use of natural light has a direct impact on the quality and quantity of other factors of standard space; such as temperature and humidity.

8. The use of daylight in space leads to better relationship with the nature and is effective on the eye health and also reduces anxiety of the people.

THE HISTORY OF USING NATURAL LIGHT

To the best of our knowledge, sunlight was first used in the 3rd century of 4th millennium to gain light and shadow by creating differences in the levels of exterior walls. In Shahr-e-Sookhteh (Burnt City), it can be found from the houses with their wall remaining under the ceiling each room had a way out through a door and there was no window. During the period of Elam Civilization about 1300 and 1400 BC, an example of glass windows has been found with the pipes from glass paste placed together in a frame and surely used to illuminate the building. One of the most ancient documents and samples of door and window in Iranian architecture may be found in the scripts of Median Castles in Dur-Sharrukin. The holes made on towers can be also found on the Assyrian reliefs [4].

During Achaemenid era, the principle of different levels was used to attract the light. According to Professor Wolfgang, it appeared that the angles of Persepolis buildings were deviated so that the first day of the year and different seasons could be determined by creating various contrasts. This deviation of angle would allow Iranian architect to build places to live in a way that every house can use necessary amount of sunlight in different seasons of the year. Sassanian also tended to show the conflict between light and shadow, and it is evident in all their buildings.

ELEMENTS CONNECTED WITH NATURAL LIGHT IN IRAN’S TRADITIONAL ARCHITECTURE

Based on the above mentioned discussion, the elements connected with natural light in Iran’s traditional architecture can be classified as follows:
The first group adjusts the light entering the building and it is divided into two categories: those which are a part of building such as porch, and those added to building and considered decorative such as curtain. The elements proposed as lightwells have different names but they are all lightwells, including: vent, lattice, latticed door and window, Jam Khaneh, Horno, sash window, Rowshandan, Freezokhoon, Goljam, Palkaneh, Fenzer, Pajang, and Tehrani. In contrast, there are some elements, such as the porch, curtain, sunshade, awning and penthouse that control and adjust the light entering the building. In addition, some elements like Shabak (lattice), control the light in addition to attraction. In the following, we explain some of them:

**LIGHT CONTROLLERS**

Porch is a space including the roof and column that is blocked at least on one side and protects human against raining and sunlight. It also passes a gentle light inside in areas where the intensity of light and heat of the sun is high, and in this case we will have an indirect light (Fig 1).

Sunshade: Sunshades are blades with 6 to 18cm in width and their height sometimes reaches to about 5 meters that have been made of plaster and reed. A skein is usually winded at the top of doors and windows that was in fact the horizontal sunshade by which the entry of sunshine to the space was controlled (Fig 2).
Awnings: creating a shadow on the windows prevents from direct sunlight to the window, and thus the heat generated from the sunlight in the space behind is significantly reduced. Sunshades may have different effects including controlling direct sunlight inside, controlling light and natural ventilation. The function of sunshades differs by their color, installation place toward the window and also natural ventilation conditions. The sunshades are divided into mobile and fixed types as well as natural shades like trees.

LIGHT WELLS:

Lattice: Iran`s changing weather, quick and clear sunlight, wind and rain, storm and tornado and specific national and religious ideas required buildings to have a lattice or curtain, in addition to two windows, to protect inside the building. Inside the building as protected with vents, wooden or plaster windows and curtain. Outside the building was also covered by crockery or tile networks that reduced the intensity of light and passed weaker light. Light rays’ deviation in collision with stained crannies helped the uniformity and emission of light. Although the entire outer space was easily visible from the inside, there was no view to the inside during the day (Figure 5).

Vent: vent and window cannot be separated. In fact, vent is a small window usually used at the top and sometimes on both sides of the door to attract light and supply air for free spaces. In other words, vent refers to the holes installed in the shoulder of arcades. Vent was sometimes made of wood and sometime of plaster and earthenware and it has been often fixed. In buildings with central and introversive structure where adequate light was supplied from the porch roof or other parts, the vent was at the top of the entrance. (Figure 3)

Sash window: sash is a latticework window that opens up instead of turning round on its heels. Sash window is usually seen on the floor of summer houses and the forehead and porch of winter buildings. The role of sash windows is usually like wooden windows and holes. (Figure 4)

Rowshandan: In buildings where the use of window in the wall was impossible such as markets and other public buildings, architects have created some vents in the solar ceiling that allows passing the light and ventilation. Rowshandan is usually like a gazebo and made of glass networks on the solar ceiling that some of them have glass, some have a polygonal context such as Rowshandan of Hasht Behesht Palace in Isfahan.
NEW WAYS OF USING NATURAL LIGHT

According to the above, in order to save energy in the building we should search for a system that can direct natural light into the building with regard to its benefits and without the limitations of window and light wells. The system is called light tube and widely used in developed countries. This system consists of three parts including collector, director and diffuser. In this technology, the sunlight enters the room through a cylinder. A cylindrical aluminum body covered in silver with high reflection coefficient is installed on the roof to direct the sunlight and prevent the entry of dust particles and another transparent cap is mounted in their room at the same level with the ceiling and connected to the cylindrical body in order to diffuse the light in all directions inside the building. It causes a fixed column of air inside the cylinder. This air column acts as an insulator and prevents from the influence of hot air inside the building and also the exit of hot air in winter. Light tube is also efficient in sunny, cloudy and even rainy days [5].
The system is used with the concept of applying new energy (solar energy) by reflection and intensification of daylight and sunlight in an aluminum cylinder with a mirror cover of pure silver. The light tube is made of an aluminum cylinder whose internal surface is covered by high-purity silver that reflects the colors naturally by a little reduction in total reflection and the surface’s specific performance. A polycarbonate transparent plate (collector) that prevents ultraviolet rays of the sun is on top of it as the sunlight absorber and also prevent the influence of dust into the system. [5]

There is also a polycarbonate diffuser plate (diffuser) at the ceiling to diffuse the light into the room. The surface of this plate has lines for better diffusion of light. The light tube has high performance either in cloudy or sunny weather. There are no potential restrictions for the length of light tubes, or the number of knees in it. But every meter in pipe length creates about 10 % decline in the light. [6]
The system can be used for all flat or diagonal ceilings. Very easy and low-cost installation are among its benefits; because they do not need structural changes in the building and can be easily mounted between girders.

**THE SAMPLES USED IN BUILDING**

This system can be used for lighting dark rooms in every floor of the house, even the cellar, as well as workshops, factories, education places such as schools and universities, the corridors of public places, hospitals, offices and dormitories and also commercial centers, shops and mosques.

**Figure 8**: The performance of light tube

**Figure 9**: Use of light tube in the ceiling

**Figure 10**: Use of light tube in commercial centers
MIRROR CONTROLLERS (HELIOSTAT)

In this method, a number of mirrors are installed on ceiling or open space that can follow the direction of sun. The mirrors can direct the sunlight into mirror tubes and then the light can reach the target level after several reflections and passing through various obstacles. with the use of these systems, the light can be directed to the depths underground.

One of the buildings uses daylight in this way is the new building of “Hong Kong and Shanghai Bank” designed by Norman Foster. In this building, it has been tried to illuminate the entrance hall with over 30 meters of height using a giant concave mirror. Using a mirror outside the building, the light is first reflected into the building and then it is redirected by 90 degrees using the second mirror and finally the light is projected to the entrance hall from above.

Figure 12: Use of light tube in commercial centers

Figure 11: Use of light tube in cellar

Figure 13: Mirror director components
**CONCLUSION**

The results of this study show that the design of daylighting adheres precise rules and includes the following four stages:

The first stage is controlling the conditions of space neighborhoods. At this stage, with regard to the importance of access to daylight and the share of skylight and reflection of external facades in the interior illumination, it has been tried to choose the volume of building and adjacent spaces so that the sky views in the section, façade and mask of the interior space are in good condition.

The second stage is controlling the depth and geometry of space. The depth of all spaces is considered to be less than the light penetration depth. One of the reasons for this decision is the necessity of controlling daze in these spaces.

The third stage is designing specific spaces. The spaces in basic and long axes (yard) use the yard and location scene to the best and have got different design and geometry.

The fourth stage is design in the middle layers with no direct access to the daylight. There are spaces in these layers illuminated using the roof lightwells and indirect lights of adjacent spaces.

All these cases are the teachings learned from lighting in a traditional building and can be a useful and practical guideline for natural lighting in modern buildings. In other words, this study suggests that natural lighting, unlike artificial lighting, should be addressed from the beginning of the design and initial ideas and considered by the architect in various stages of the design from general ideas to details. There is hope that today’s architects also have environmental concern such as architects in the past and use up-to-date science and technology to enhance the quality of their projects.

So given that Iran is a sunny country and considered as the best countries in the world in terms of solar energy absorption, the use of this natural resource is essential. This energy can be expanded across the country without the need for costly energy transmission and distribution networks, but unfortunately the use of solar energy is insignificant in spite of new science and technologies in the country. It is believed that great sources of oil and gas caused the lack of progress in the use of solar energy. However, the rise in energy prices and reduction of fossil energy resources have revealed the necessity of applying new energy especially solar energy in Iran more than ever. Hence, experts and engineers have to contribute to save and preserve renewable energy sources for future generations by using new methods.

Using new methods such as light tube system and mirror directors is a step for greater use of solar energy and also saving electrical energy in administrative, commercial and educational buildings. The investment costs in these systems are quickly returned.

Furthermore, using these systems in buildings can significantly save renewable resources and thereby prevents from environmental degradation and global warming in addition to protection of natural resources.
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