The Effects of Utilizing Natural Light to Reduce Energy Consumption

Shilla SHEIKH1*, Afsane GHALEHNOVI2

1* MSc in Urban Planning, Science and Research Branch, Islamic Azad University, Tehran, Iran
2MSc in Architectural Energy, Tehran University, Kish International Campus, Kish, Iran

Received: 22.03.2015; Accepted: 29.05.2015

Abstract. While Iran has the richest energy source, but wastage and improper use of it has imposed irretrievable damages to our annual budget; such that construction division has allocated the most level of energy to itself with more than 40% of total energy produced in Iran and consumption of expenses equal to 30% of earning gained from oil sale. Since electricity energy has the most share of energy consumption in construction division, providing modern ways to reduce the consumption of this energy is necessary. Meanwhile using natural light in spaces has effective role in energy efficiency and preventing from dissipation of electricity energy since usual solutions in the modern time, namely using electrical illumination systems will result in space heating and bodily (eye) damages, beside very much expense. In this article, after mentioning the benefits of natural light in buildings, we will address the manner of using natural light in ancient architecture and finally will develop and discuss the modern methods of using this natural source like sun pipes, mirror conductors which other countries have used.

Keywords: The least natural light, reducing energy consumption, sun pipes, mirror conductors

1. INTRODUCTION

Solar energy is a source of providing free energy, clean and free from the destructive environmental effects which have been used from ancient times by human being and in different ways. Energy crisis in the recent years has made world countries to encounter differently with the problems relating to energy and among them substitution of fossil energies with retrievable energies including solar energy has been welcomed very much in order to reduce and save energy, control energy demand and supply and reduce the diffusion of pollutant gases (1).

Using solar energy in buildings has been one of the most ancient applications of this energy, but what was paid more attention is using heating energy of the sun about which many materials have been discussed and researches and results have been developed. But in Iran using sun light directly to provide energy has been paid less attention, while with advancement of technology and material science, new methods have been innovated in this relation which will be discussed extensively in this article.

In construction art or in other words architecture, light is a component which is discussed beside other elements and concepts like spatial structure, materials, color and so on and plays its role in designing as a separate element. But the fact is that in most cases in construction and interior architecture, light is regarded as an illuminating factor which will result in reduction of artificial light and so that reduction of electricity consumption but contribution of natural light in providing illumination of building should be made while paying attention to confrontation with absorption of undesired heat.

*Corresponding author. Email: Shilla SHEIKH

Special Issue: Technological Advances of Engineering Sciences

http://dergi.cumhuriyet.edu.tr/ojs/index.php/fenbilimleri ©2015 Faculty of Science, Cumhuriyet University
The benefits of using natural light in architecture

Utilizing natural light has many advantages and benefits, some of which are discussed here briefly:

1. Reducing energy consumption: less dependence to artificial light will contribute to 10% reduction in the use of electricity.
2. Reducing the microbial factors and fungi inside the buildings: most illnesses especially respiratory chronic problems are related to bacterial elements and fungi produced in humid parts of the building like underground and bath. Natural light could naturally reduce the production of harmful organisms and sun light is considered as one of the best disinfectants.
3. Healthiness resulting from the consumption of vitamin D: Sun light in large quantities may prevent from deficiency of vitamins D and B1 which may cause illnesses like rickets and Beriberi.
4. Improving efficiency resulting from changes in work environment: in many cases, we have concluded that in places which use natural light, we observe considerable improvement in personnel efficiency.
5. Increasing visual attractions in interior design: natural light is still one of the best types of lighting systems used in interior design and may be a challenging and at the same time satisfying job in combination with structure or building.
6. Day light because of possessing ultra violet ray is considered as one of the factors creating natural rhythm in biological systems of body.
7. Using natural light has direct effect on quality and quantity of other factors of standard space like temperature and humidity.
8. Using day light in the space will result in more relation with nature and is effective in persistence of sight health and will end in reduction of anxiety of people.

History of utilizing natural light

The first date recorded for using sun light was the third century of fourth millennium B.C. when in order to get light and shadow level difference on exterior walls were used. In the burnt city of third and second millennium B.C. the monuments of houses whose walls till roof had been remained showed that rooms were connected to outside just with a door and had no windows. In Ilam period about 1300-1400 B.C. examples of glass windows were obtained that included tubes made from glass paste accommodated beside each other in a frame and certainly used to illuminate inside the building. Of the most ancient documents and examples of doors and windows in Iran architecture may be found in the Median castles of DorSharkin works. The Assyrian raised designs makes identifying windows built on the towers possible. In Achaemenian period, the principle of level difference was utilized to absorb light inside the houses. Researches of Prof. Wolfgang shows that angle deviations of Takht-e-Jamshid buildings were founded on the principle according to which the first day of year and different seasons were identified by creating different light and shades and this deviation allowed the Iranian architect to build the places required for living so that in different seasons of year, houses could use sun light as necessary. Sassanians were also willing to show the contrast between shadow and light and this may be seen in all buildings remained from that period.

Elements related to natural light in Iran traditional architecture

According to above mentioned materials, elements related to Iran traditional architecture may be classified and studied as follows:
The Effects of Utilizing Natural Light to Reduce Energy Consumption

The first group has the function of adjusting the light entered into the building and are divided to two classes: first those which are part of the building like porticoes, and second those which are added to the buildings and are sometimes decorative like curtains.

Elements discussed as windows have different names but all are skylights and include: casement, terillis, cup home, sash window, and Tehrani. Elements like portico, curtain, and sunshade and so on are responsible for controlling light and regulating it for entering inside the building. Besides, elements like terillis both get light and control it. In the following, some of them are discussed:

**Light controllers**

Portico: a space including roof and columns which is enclosed at least in one side and keeps human being from contact with rain and sunlight and where light intensity and sun heat is high, it passes suitable and mild light inside and in this case we will have indirect and mediated light. (Fig. no.1)

Sun breakers are partitions with the width of 6-8 cm. which sometimes their height reaches to 5 meters; they were built from plaster and reeds. Usually a dovetail joint was drawn above door and window which was in fact horizontal light screen and called sar-saye (head shadow) and used it to control the entrance of light into the space. (fig. no.2)

Canopies: creating shadow on the windows would prevent from direct radiation of sunlight to the window surface and so the heat produced because of sunlight in the space behind it would decrease significantly. Canopies may have different effects like controlling direct radiation of light to inside, light control and natural ventilation. Effectiveness of canopies is different and depends to their color, location relative to the window and natural ventilation conditions in the building. Canopies are divided to fixed, mobile types and natural canopies like trees.
Sky lights

Terillis: Iran variable weather, bright and intense sunlight, wind and rain, storm and whirlwind and special national and religious ideas required that buildings have a curtain or network, besides two windows, to protect interior space of the buildings. Inside buildings were protected by wooden, plaster windows and curtain and outside were covered by ceramic terillis or tiles. These terillis would reduce the intensity of light and weaker light pass them. Deviation of light radiations would diffuse because of hitting the painted edges of network and contribute to the uniformity and diffusion of light. And while outside was easily visible from inside the building, no one could see inside the building during day. (Fig. no.5).

Window in different sizes may not be discriminated from each other. In fact, casements are usually are devised above door and sometimes around it to get light and provide open air for enclosed spaces. In other words, they are casements installed in the tassel or shoulder of roofs. They were sometimes built from wood, plaster or ceramic and were usually fixed. In buildings with central context and introverted and sufficient light was provided from the roof or another part of entrance hall, casements were installed above entrance door. (Fig.no.3)

Sash windows: sash is an openwork window which instead of revolving on the heel, gets up and is located in the case considered for it. They are almost seen in stories of palaces and the portico of building in cold regions. The network design of sash windows is mostly like wooden windows. (Fig. no. 4)

Roshandan (bright space): in buildings where devising windows in the wall was not possible, like bazaars and other public buildings, architectures made casements to pass light and ventilation in the best possible way and called it light space. They were usually like pavilions and network patterns were installed in them; some of which had glasses; some were polygonal like the bright space in Isfahan Hasht-Behesht Palace.
New methods for utilizing natural light

Considering what was explained, in order to save energy, we should try to find a system that can conduct the natural light with its benefits and without the deficiencies and limitations of window and skylights into the building. This system has been utilized in most advanced countries and is known as sun pipe or solar channel.

This system is made up of three parts: collector, conductor and diffuser. In this technology, sun light enters the intended room through a cylinder. An aluminum cylinder frame covered with silver with high reflection coefficient is installed on the roof to conduct sun light and prevent from entry of dust; another transparent cover is installed in the room aligned with the roof and is attached to the cylinder frame to diffuse light inside the building in all directions and creates a stationary column of air in the cylinder. This air column acts as an insulator and prevents from permeation of warm air into the building and outflow of warm air from the building in winter. Sun pipe has the required effectiveness in different climates like sunny, cloudy and even rainy weather.

This system employs new energy (solar energy) through irradiation and intensifying sun light and day light in an aluminum cylinder with a cover of pure silver. Sun pipe is made of an aluminum tube with interior surface covered with silver with high purity and by very slight decrease in general reflection causes that different colors be reflected in the best way naturally. A polycarbon transparent plane (collector) which prevents the ultra-violet ray of sun is located above it and acts as a light absorber and also prevents from the permeation of dust into the system. (4)

A polycarbon disseminator (diffuser) is devised on the roof to diffuse light into the room. The surface of this plane has lines to better diffuse light.

Figure 6 &7: Elements constituting sun pipe.
Sun pipe is very efficient in cloudy and sunny weather. Potentially, there is no limitation for the length of sun pipe or the number of knee joint used in it. But for every one meter length of the tube, we will have 10% reduction in light provided. (5)

This system is applicable for all diagonal or plane roofs. Its main benefits are easy and cost-effective installation, because they don’t need structural changes in the building and are easily located between iron beams.

**Examples of utilization in buildings**

This system may be applied for illumination of dark rooms of houses in different floors even underground, workshops, factories, educational places like school and universities, hallways of public places, offices, hospitals, dormitories, and also illumination of commercial places, shops and mosques.

![Figure 8. Sun pipe function.](image)

![Figure 9. Using sun pipe on the roof.](image)

![Figure 10. Using sun pipe in commercial centers.](image)

![Figure 11. Using sun pipe in underground.](image)
The Effects of Utilizing Natural Light to Reduce Energy Consumption

**Mirror conductors (Heliostat)**

In this method, mirrors are installed on the roof or open environment which may follow sun movement path. These mirrors may conduct sun light to mirror tubes and sun will reach the intended surfaces after several stages of reflection and passing from different barriers. In this way, the system may conduct light to several meters underground.

One of the buildings which utilize sun light very beautifully in this way is the building of Hong Kong and ShangHai bank by Norman Foster. It has been tried in this building to illuminate the entrance hall of the building with the height of more than 30 meters with a giant concave mirror. At first light is reflected inside the building by the aid of a mirror outside the building and then second mirror changes the direction of light 90 degrees and irradiated from the above to inside the entrance hall.

![Figure 14. Conducting sun light by mirror conductor.](image)

![Figure 15. Hong Kong Bank](image)

### 2. CONCLUSION

Since Iran is a country very much sunny and is considered as one of the best countries from the point of view of level of solar energy, using this natural source is regarded very natural. This energy doesn’t require expensive transfer and diffuse networks and is expandable all over the country but unfortunately nowadays considering the new science and technology in Iran, using solar energy is very small. It is believed that huge sources of oil and gas have led to lack of improvement in the field of solar energy, but gradually with the increase of energy price and reduction of fossil energy resources, the necessity of using new energies especially solar energy in Iran has become more obvious. So specialists and engineers should utilize modern methods to contribute to saving and maintenance of irretrievable energy resources for future generations.

Using new methods like illumination systems of sun pipes, mirror conductors is a step towards using solar energy and also electrical energy saving in different sections of domestic, administrative, commercial and educational.
And also the expenses of investment in systems are easily accessible.

In addition to the mentioned items, by using these systems in building construction, we may save a lot in consumption of irretrievable resources and in this way, besides protecting natural and constructional resources prevent from the destruction of environment and increase in the temperature of earth.

REFERENCES