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ORIGINAL RESEARCH PAPER

Researching on Sustainable Architecture in Approach to Energy Efficiency

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ABSTRACT: Since most of the annual energy consumption in each country is related to the construction, optimization of energy consumption in buildings is important. When a single issue of energy is investigated, especially in residential buildings, design standard and specific rules could be seen that to achieve solutions for low energy consumption, helping. Of course, these rules depending on the occupation levels, receive heat, heat loss and building diversity of users are different and therefore are not easily standardized. In addition, a solution for a successful commercial or industrial building is not automatically to be used for other buildings. For example needs of heating, cooling and lighting and heat absorption capabilities of people, equipment, lighting and the sun should be in relation to building form, orientation, structure, pattern of occupation and environmental needs are assessed to ensure that all the points already are to appear on the general design decisions to be applied. So this article is trying to introduce the factors affecting energy consumption, the proposed solutions will be based on the lowest consumption in the construction, and eventually reached a sustainable design.

Keywords: Energy, Sustainable Architecture, Climate, Solar architecture, Thermal comfort

INTRODUCTION

Considering the environmental risks, either real or possible, which threaten the quality of our lives, environmental movements in every section of industrialized countries, including business, production, transportation, agriculture and architecture has been set up.

Developing countries wish to establish their economic infrastructure in accordance with the infrastructures of developed countries. The economic quantitative indices, such as per capita income, gross national product, the size of foreign business and the amount of construction all demonstrate that the economies of these countries are rich and are growing rapidly (Zibafar 2005).

The society today, passing from a traditional life and moving toward attaining an ideal society, a Utopia, has faced major challenges. Limited energy resources and environmental damages caused by the excessive use of energy resources are two of the greatest problems that challenge the science and industry communities. The climate change, global warming, Ozone layer depletion and acid rains are indicative of lack of economizing and optimized use of non-renewable energy resources (Marefat, Omidvar2008).

By increasing the level of income in a society, the consumption of resources and reservoirs will increase as well. This is a fact which holds true in any society with any size, be it a family, a city or a whole country. Among industrialized countries, Canada and the U.S. have the highest consumption of energy while Japan's consumption is much lower. This comparison proves that with regard to

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energy resource consumption, a society can optimize and make efficient the social and economic infrastructures parallel to economic growth. Any society with such an infrastructure is hardly in danger of facing shortcomings in resources and as a result, will be more sustainable in future (Zibafar, 2005).

Sustainability in Architecture

The world commission on environment and development has defined sustainability as follows: meeting the needs of the present without compromising the ability of future generation to meet their own needs. Optimized use of non-renewable sources of energy is important not only from an economic point of view, but also from an environmental point of view. Although maintaining and reinforcing economic institutions is vital in achieving sustainable development, saving the environment for present and future generation is our responsibility (Marefat, Omidvar 2008).

Architecture is one of the most outstanding forms of economic activity. It is proposed that intensity of (consumption of) architectural resources (the ratio of per capita consumption of architectural resources to per capita income) generally follows the same pattern. A country's economic development necessitates building more firms, official and residential buildings (Zibafar 2005).

Sustainable Design Principles

In order to achieve the mentioned coexistence, awareness about environment, clarification of environmental system of buildings and teaching the design of sustainable buildings seems mandatory. Professional architects should accept the fact that by the improvement of economic condition of a society, its demand for architectural resources increases. This in turn will increase the overall impact of architecture on global environment system which encompasses anti-organic, live organisms and human. The goal of sustainable design is to find architectural solutions that guarantee a proper environmental condition (Zibafar 2005).

General Principles of Energy Management in Construction Systems

Energy management in buildings can be studied with respect to several factors: the place of the building, building coverage and building systems.

Selecting a building's place determines the weather condition that the building will be exposed to. Building coverage determines the effect of local conditions on residents of a building. Building's systems complement the heating and cooling powerand the accessible light of the surrounding environment. As far as using these complementary systems relate to the building's coverage and its local particulars, energy consumption can be minimized.

Buildings have a close connection with the air condition. This connection includes factors more than temperature. Human beings' comfort is dependent on thehumidity, the velocity of air flow and also the temperature. Absorption and wasting of energy in buildings depends on these factors as well as velocity of solar energy, shadowing of trees or hills, wind speed and the length of hot and cold seasons.

In order to achieve sustainable buildings, insulation, optical materials, selectinglayers and radiation barriers can be used.

Climate Divisions and Architectural Typology

The diverse characteristics of each climate have a great impact on the formation of cities and architecture structure in that area. Therefore, the accurate determination of climate zones of different areas is very important in presenting proper designs congruentwith the climate of each area.

One of the vital issues in construction, residential areas and an climaticarchitectureis the issue of warming them in cold seasons and cooling them in warm periods of year to reach the limits of human beings' heating comfort; as a result, considering specific arrangements related to shape, windows' size, the nature of building materials and climate conditions can lead to the most possible saving in heating and cooling residential areas. The critical issue in understanding the architectural value of each period and each area knows how to adjust a building with the special climate of that area. How the building makes use of the sun, breeze and greenspace and how the architect creates a small weather climate (Behyar, Khoozani, Bagheri, 2002).

Another factor that reduces the effects of climatic factors on buildings is the size of the building. If we quadruple a shape, the ratio of its volume to its surface will decrease from 1.6 to 1.15 and as a result of the decrease in the outer surface to the covered volume, the effect of climatic factors will lessen.

However, some principles for buildings can be pro-

posed, which are as follows:
1.In cold areas, closed and compact forms and cubic buildings or adjacent buildingsat the back across the north-south axis are preferred. In such areas, high buildings are more suitable.
2.In mildweather, it's easier and freer to choose a form, but anyway, the forms along the axis of east-west are preferable.
3.In hot and dry areas, solid and compact forms are advisable. Cubic forms or forms which have a bigger north-south side in comparison with their east-west side are better. High buildings are also preferable to short buildings.
4.In humid areas, buildings that freely extend along the east-west axis suits better, but the buildings which extend along north-south axis are not suitable because they are exposed to acute sun shine (Kasmayi, Ahmadinejad 2006).

Thermal Energy

Creating a healthy and pleasant environment for living in different seasons of a year has always been a vital issue for human beings. The rapid progress of science and technology has led to human beings spending more than ninety percent of their time in closed places such as factories, residential complexes and transportation vehicles. Therefore, the necessity of achieving a heating and cooling system which can create a healthy and enjoyable condition in the building has become obvious (Marefat, Omidvar, 2008).
Generally, comfort condition can be categorized in some major branches: qualitative comfort, acoustic comfort, visual comfort and thermal comfort. The quality of the weather and the conditions of living and work places regarding air pollutants is an important and effective factor in creating comfort (Marefat, Omidvar, 2008).
The body's thermal comfort is provided when the temperature of the skin is 34^{o}C. Most people will feel comfortable when the temperature of the environment is 22^{o}C. The 12 degree difference between the above mentioned temperatures are because of the 60 watt heat caused by metabolism of food in our bodies.
Heat exchange between man's body and the surrounding environment is done in four ways:
1.Conduction (caused by direct contact)
2.Conduction – transfer (movement of the air)
3.Vaporization – transfer (moisture of the skin)
4.Radiation (solar and thermal)
In building design and the technical issues related to that, a humanthermal comfort is defined as the state of mind that expresses satisfaction with the surrounding environment. Many of the scholars in this field believe that "thermal neutralization" is a more precise definition for thermal comfort because in such a situation the body feels neither cold nor hot, there is no local discomfort caused by unbalanced radiation, current of air, coldness of the floor, discordant clothing etc. (Behyar, Khoozani, Bagheri 2002).
The temperature of things, elements and also materials and different paints should be taken into account. In hot weathers, isolation or other materials are used erroneously that cause problems such as coldness of the rooms. Utilizing concrete or steel construction material in very hot, dry or very cold places may result in their cracking or breaking down. In the neighboring areas of tall buildings, the sun's radiation is not direct; it's mostly reflected and refracted.However, in open areas with short buildings the major part of sun's radiation is direct and the resulting difference in temperature of shadows and sun-shine areas will lead to high thermal tension which must be considered at the time of planning and performing (Behyar, Khoozani, bagheri, 2002).

Investigating Thermal Comfort Methods

Presently, two methods have been proposed to determine the thermal comfort inside the buildings, namely: statistical method (field research method) and the method based on the physics of heat transfer between human body and its environment (analytical method) (Marefat, Omidvar 2008).

Simultaneous Analysis of Thermal Comfort and Energy Consumption in Building

In order to predict the terms of thermal comfort in a building and also to analyze the performance of heating and cooling systems regarding energy consumption and thermal comfort so that one can select a suitable ventilation system or optimize the performance of these systems with respect to the climatic conditions, local traditions and customs and present limitations, the interior space of a building must be modeled from a thermal point of view.
Generally, the heating and cooling systems of buildings can be divided into two major categories, ra-

diation systems and convection systems. Floor heating systems and also ceiling-mounted cooling and heating systems are among the most important and most practical radiant ventilation systems. Radiator, fan coil and evaporation coolers are among convection heating and cooling systems (Marefat, Omidvar, 2008).

Considering the vast use of central heating systems in our country, Iran, it seems that optimizing these systems to reach high efficiency and finally to reduce the costs and energy consumptions is inevitable.

On the whole, in a central heating system, the potentials of economizing energy consumption can be summarized as follows:

•Preventing energy waste of central heating services and transporting machines

•Reducing energy consumption surplus by boilers and subsidiary equipment

•Preventing unnecessary working of energy consuming machines which lack an independent control system

•Using suitable controllers to control heating (Sharif 2006)

7.2.Optimization Methods of Energy Consumption in Ventilation Systems of Buildings

1.Minimizing the functioning time of ventilation equipment by installing instructional placards

2.Minimizing the functioning time of ventilation equipment by entrusting the duty of turning on and turning off of the ventilation equipment to reliable staff

3.Minimizing the functioning time of ventilation equipment by installing adjustable thermostats or space controllers

4.Minimizing the functioning time of ventilation equipment by installing timed disconnecting switches (Sharif, 2006)

Electric Energy and Saving Techniques

Lighting system is one of the most important consumers of electric energy. Among the overall electric energy consumed in lighting system, 63% is allocated to official buildings, 22% is allocated to residential buildings and 12% is used for streets and roads (Sharif 2006).

Lighting system is used for illuminating different places. This system transforms the electric energy to light. A lighting system is comprised of an electric part and a non-electric part and has different parts including an power supply, launching equipment, ballast control, lamp and light (Sharif 2006). Designing a lighting system means determining the number and kind of lamparrangement for a specific place; in a way that the intensity of the lighting in that place suffices for the intended purpose (Sharif 2006)

In accounting for interior lighting,dimensions i.e. length (L), width (W), height (H) and effective height (h) are considered as the parameters of the place (Sharif 2006).

9.2. Compiling an Energy Consumption Management Program for Lighting Systems

The stages of an energy consumption management program for lighting systems are as follows:

1.Measuring the size of current lighting surfaces

2.Proper use of daylight

3.Improvement proposals with existing equipment

4.Evaluating alternative options and installing new equipment (Sharif 2006).

Conclusion

Methods of Reaching a Sustainable Design

The final goal and challenge of sustainable design is to find a successful way that encompasses qualitative, quantitative, physical and mental advantages. To reach this seemingly difficult goal, there are several potential possibilities. The threefold principles of sustainable design provide useful information about environmental issues related to architecture. Techniques relating to each of these three principles focus on more specific and special issues. These techniques aim to establish a correct understanding of the correlation between each building and the global, local and internal environment.

Technical Points for Designing Sustainable Buildings

From an environmental point of view, paying attention to the climate and lifestyle is an appropriate way for fulfilling architectural needs and obtaining a comprehensive view for designing. To achieve successive success, the designers have to increase their knowledge about new designing philosophies and the relation between interior and exterior spaces. The relation among form, structure and comfort depends on the particulars of the building's orientation, site and education.

The following methods are proposed for applying

sustainable design to architecture.

Saving Energy

Saving energy is one of the methods of reducing the entrance flow. The major aim of this technique is decreasing consumption of fossil fuels. Buildings consume energy not only while they are in use for heating, cooling and lighting purposes, but they also consume energy while they are being built. Consumed materials in architecture are firstly extracted and taken from raw materials, then they undergo production processes and finally they are taken to the building's site. At the stage of construction, large amount of energy is used for different activities ranging from excavation to welding.

Energy-informed Planning for a Site

Such planning enables the designers to maximize the use of natural resources available in the site. In mild weather, devising openings on the south side of a building increases the passive solar heating; deciduous trees cast shadow in summers and, in winters, they make receiving the sun's heat possible. By planting evergreen plants on the north side of a building, it can be protected against winter winds and one can improve the energy consumption efficiency of it. To provide natural cooling condition in summers, buildings can be situated near water resources in the site.

Passive Cooling and Heating

The sun's radiation flash to the surface of a building is the most considerable energy entering it. The Sun's radiation provides the heat; light and ultraviolet light necessary for the process of photosynthesis. Throughout history, architects have been trying to utilize forms which cast shadow in summers and have proper warmth in winters. This important prerequisite is often neglected in designing modern buildings. Passive solar system architecture provides us with solutions and arrangements so that the sun's radiation can be used in more beneficialtimes of day.

By providing shadow with the help of awning or plants, one can prevent receiving the heat in summers and subsequently, the imposed charges for ventilation service. Wind or the flow of air has been two important advantages among the major urban planning issues. For instance, the structure of Roman cities was principally based on the direction of dominant wind.

Insulation

Windows with high efficiency and insulation of the walls prevent receiving and wasting heat. Reducing such heat transfer will decrease the amount of heating and cooling charge of a building and consequently, the amount of energy consumption. Less heating and cooling charge requires smaller ventilation systems. Moreover, the costs spent on these systems will reduce.

These tangible and objective advantages, highly-efficient windows and insulated walls provide more appropriate heating conditions in practice. Because of the particulars of insulation materials, the heating degree of windows and walls are higher in winters and lower in summers. Utilizing smaller ventilation equipment decrease the noise of mechanical machines and increase the audio quality of interior spaces.

Alternative Energy Resources

The wind, water, geothermal (earth's heat) and solar energy systems are all available from a market point of view. Therefore, the demand for external energy resources will be reduced or eliminated. Electrical or heating equipment can be applied with these systems or a combination of these systems in any weather condition.

After the costs of construction, the major cost of a building belongs to its maintenance and usage. During the course of a building's existence, these costs may surpass the costs of construction. As a result, accurate selection of low-consumption heating and cooling and ventilation systems seems necessary and mandatory. The prices and charges of thisequipment might be higher than low quality equipment, but these charges will be compensated for by future savings.

The amount of energy needed for different types of building material is different. The essential energy of building material indicates the total amount of energy consumed in the whole cycle. For instance, aluminum has got a very high essential energy because high level of electric energy is needed to produce it out of bauxite ore; however, recycled aluminum needs a lot less energy to be reproduced. Choosing materials with a lower essential energy reduce the overall impact of building on environment throughout its lifetime. By making use of

local material instead of imported material of the same kind, the energy needed for transportation will be saved.

The water used in a building can be divided into two groups: sewage or gray water or wastewater. Gray water is the water generated from activities such as washing. Although its quality is not parallel to drinking water but it doesn't need purification like wastewater. In fact, it can be recycled again in the building, and it can be used for purposes such as watering decorative plants or toilet siphons. Using good and well-designed piping systems can facilitate it.

In most parts of the world, the atmospheric precipitation on buildings is not a good source of water production. The buildings are usually designed in a way to protect their residents from rainfalls and the idea of using rain water poured on buildings is not widely experimented. The outershell of the buildings, especially ceilings, if combined with water tanks can be used for irrigation or for siphon of bathrooms.

The system and equipment related to water supplies in buildings can be chosen in a way to reduce the amount of energy consumption and waste. In many parts of the U.S., it is mandatory according to the rules and regulations that low-intensity water taps and low-volume toilet tanks be used. Suction toilets and bio-compost can reduce water consumption to a large degree. Bio-compost toilets purify wastewater in them and therefore, remove the need to energy-consuming procedure of urban purification.

Natural landscaping – using local plants of the area – is also influential in reduction of water consumption. Such plants are adjusted to the rain level of the area and don't need extra irrigation. Where irrigation is necessary, attention must be paid to adjust the sprinklers so that water does not spatter on sidewalks and streets.

Production and consumption of construction materials have various effects on local and global environment. The exploitation, processing, production and transportation of construction materials all involve environmental damages. In order to save and reduce consumption, methods for decreasing outflows andinflows must be used. Here, like for water, some of these methods overlap.

One of the most direct and influential methods of saving materials is using sources which exist before the building is built. Most buildings last more than the purpose for which they are designed; many of them – though not all of them – can be transformed to serve other purposes with less cost.

Those building which have no other way but destruction must be used as sources of constructing new buildings. Many construction materials like wood, steel and glass are easily recycles and transformed to new materials. Some others, like bricks, or windows, can be used completely with the same form in new buildings. Furniture and especially new systems of official partitioning can easily be used in new conditions.

In the process of planning for a building and choosing construction materials, we should search for ways to apply recyclable materials. This property prevents wasting the energy consumed during the process of production.

If a building is larger than the size necessary for the intended application and purpose, or if the size of its systems is larger than needed, the applied material will be more than the appropriate amount as well. When a building is very large or very small compared to the number of those who use it, the heating, cooling and ventilation systems which naturally fit the size of the building will be insufficient or inefficient. This method is directly related to the stages of planning and designing the architectural process. To make sure about the dimensions and size of the designed building and its systems, the current and future needs of employers must be studied.

Architects are encouraged to design buildings on the basis of standard building dimensions as much as possible. Extra materials will result in more wastes for adapting their size with non-modular spaces.

Products such as recycled tires of cars, beverages' cans and farming wastes can be considered as unusual sources which are easily available as construction materials; such substances reduce the need for waste excretion fields. Furthermore, these substances have less essential energy compared to more common substances.

By movement of clouds and the sun in the sky, its light changes. Every human being enjoys an internal clock which is adjusted to the cycle of day and night. From a psychological and physiological point of view, windows and sky-lights play an important role in adjusting the body's clock.

Adjustable windows are very vital because it allows the residents to monitor and control the temperature and ventilation of their place to some extent.

Fresh air which enters the rooms through clean channels is crucial for the health and comfort of the building's residents. Fresh and clean air has a more important role than providing the oxygen. Internal circulation and closed movement of the inside air expose residents of interior spaces to a huge amount of bacteria and chemical compositions.

One of the important aspects of sustainable design is its lasting ability. Durable buildings which are consistent with the situation are more sustainable than others. A part of this consistency refers to its responsiveness towards people of different age and different physical conditions. The more people can use the building, the longer its effective life will be.

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