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BUILDING AND CONSTRUCTION: MILESTONES OF GREEN ARCHITECTURE TOWARDS SUSTAINABILITY

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Abstract- In the face of ever-mounting costs of fuel gas, fuel oil, and electricity, more and more people are giving serious thought to using solar energy in their struggle to make ends meet. Naturally, the built-up environment surrounds us and is constantly evolving to meet our changing needs and lifestyles. Encouragingly, in passive solar building design, windows, walls, and floors have a fundamental role in collecting, storing, and distributing solar energy in the form of heat in the winter and reject solar heat in the summer. These criteria pave the way for a comprehensive incorporating a building sitting, design, construction, materials and operations in ways to enhance the well-being of the occupants and preserve our environment for future generations by conserving natural resources.

Keywords: Energy Efficiency, Renewable Energy, Green Architecture, Sustainability

I. INTRODUCTION

By the mid 1980s and continuing through the '90s, the number of environmental advocacy societies radically expanded; groups such as Greenpeace, Environmental Action, the Sierra Club, Friends of the Earth, and the Nature Conservancy all experienced burgeoning memberships. For architects and builders a significant milestone was the formulation in 1994 of Leadership in Energy and Environmental Design, LEED, standards, established and administered by the U.S. Green Building Council. These standards provided measurable criteria for the design and construction of environmentally responsible buildings. The basic qualifications are *energy matters*, *construction materials*, *context*, *recycling*. Sustainable or "green building" design and construction is the opportunity to use our resources more efficiently while creating healthier and more energy-efficient homes. Although there is no magic formula, success comes in the form a leaving a lighter footprint on the environment through conservation of resources, while at the same time balancing energy-efficient, cost-effective, low-maintenance products for our construction needs [6].

II. DESIGN WILL SAVE THE WORLD

Green architecture is an approach to building which has become more prevalent in the last decades. Also known as sustainable design, green architecture is simply a method of design that minimizes the impact of building on the environment. Once thought of as unconventional and non-standard, green architecture is quickly becoming accepted by both regulatory agencies and the public alike as a socially responsible and logical means of construction. Successful environmental design is achieved when communities are actively involved in their own planning, design and construction processes including self building where local resources, materials and labor are maximized and waste is minimized. Sometimes to preserve the delicate environmental carrying capacity of a particular place, sustainability means saying no to development. Sustainable design acknowledges our temporary stewardship of the planet, "living in Equilibrium" with the natural world within its limits [5].

III. RENEWABLE ENERGY SOURCES

About 30 years ago the world experienced a major oil crisis. The major oil crisis was the beginning of a new way of energy thinking. People started discussing about alternative energy resources, which would be renewable and environment-friendly. Even though it began 30 years ago, however the fossil fuels are the biggest group of energy resources for producing electricity. But the alternative energy resources are advancing but not as fast as they should do. The incredible low electricity price makes it impossible for alternative energy resources to compete. However in the long run it is the nature that will have to pay the biggest price, if we do not do anything radical. Among several renewable resources, solar energy is much better than the other ones in terms of *availability*. Some 92.95×106 miles away from us or for those working in metric 149.6×106 km away from us is the *sun*. To imagine the magnitude of this great distance, think that light, which travels at amazing 299, 792, 458 meters per second, takes a total of 8.31 minutes to reach us. Although the sun is incredibly far away - it is also tremendously huge! This means that although you would think that relatively little solar energy reaches us; in fact, the amount of solar radiation that reaches us is equal to 10,000 times the annual global energy consumption. On average, 1,700 kWh per square meter is insulated every year. Harper (2007, p. 9) expresses, "Now doesn't it seem a silly idea digging miles beneath the earth's surface to extract black rock and messy black liquid to burn, when we have this amazing energy resource falling on the earth's surface"? Solar energy - power from the sun - is a vast and inexhaustible resource. Once a system is in place to convert it into useful energy, the fuel is free and will never be subject to the ups and downs of energy markets. Furthermore, it represents a clean alternative to the fossil fuels that currently pollute our air and water, threaten our public health, and contribute to global warming. Given the abundance and the appeal of solar energy, this resource is poised to play a prominent role in our energy future. So, conserving energy seeks for various strategies as follows [4].

IV. PASSIVE SOLAR DESIGN FOR BUILDINGS

The techniques of passive solar building design were practiced for thousands of years, by necessity, before the advent of mechanical heating and cooling. It has remained a traditional part of vernacular architecture in many countries. There is evidence that ancient cultures considered factors such as solar orientation, thermal mass and ventilation in the construction of residential dwellings. Fully developed solar architecture and urban planning methods were first employed by the Greeks and Chinese who oriented their buildings toward the south to provide light and warmth. Nearly two and a half millennia ago, the ancient Greek philosopher Aeschylus wrote: "Only primitives & barbarians lack knowledge of houses turned to face the winter sun." Similarly, Socrates said: "Now, supposing a house to have a southern aspect, sunshine during winter will steal in under the verandah, but in summer, when the sun traverses a path right over our heads, the roof will afford an agreeable shade, will it not?" In fact, solar energy is a radiant heat source that causes natural processes upon which all life depends. Passive solar energy means that mechanical means are not employed to utilize solar energy, rather passive solar systems rules of thumb are replaced which including the following items [1]:

- The building should be elongated on an east-west axis.
- The building's south face should receive sunlight between the hours of 9:00 A.M. and 3:00 P.M, sun time, during the heating season.
- Interior spaces requiring the most light, heating and cooling should be along the south face of the building. Less used spaces should be located on the north.
- An open floor plan optimizes passive system operation.
- Use shading to prevent summer sun entering the interior.

A. Passive Solar Heating

South facing glass and *Thermal mass* to absorb, store, and distribute heat are two primary elements of passive solar heating. There are three approaches to passive systems - direct gain, indirect gain, and isolated gain. The goal of all passive solar heating systems is to capture the sun's heat within the building's elements and release that heat during periods when the sun is not shining. At the same time that the building's elements or materials is absorbing heat for later use, solar heat is available for keeping the space comfortable, not overheated [4].

A.1. Direct Gain

In this system, the actual living space is a solar collector, heat absorber and distribution system. South facing glass admits solar energy into the house where it strikes directly and indirectly thermal mass materials in the house such as masonry floors and walls. The direct gain system will utilize 60-75% of the sun's energy striking the windows.

In a direct gain system, the thermal mass floors and walls are functional parts of the house. It is also possible to use water containers inside the house to store heat. However, it is more difficult to integrate water storage containers in the design of the house. The thermal mass will temper the intensity of the heat during the day by absorbing the heat. At night, the thermal mass radiates heat into the living space.

A.2. Indirect Gain

In an indirect gain system, thermal mass is located between the sun and the living space. The thermal mass absorbs the sunlight that strikes it and transfers it to the living space by conduction. The indirect gain system will utilize 30-45% of the sun's energy striking the glass adjoining the thermal mass.

Thermal storage wall systems (Trombe Walls) and *Roof pond systems* are two types of indirect gain systems [9]:

- **Thermal Storage Wall Systems**

According to Figure 1, the thermal mass is located immediately behind south facing glass in this system. Operable vents at the top and bottom of a thermal storage wall permit heat to convect from between the wall and the glass into the living space. When the vents are closed at night radiant heat from the wall heats the living space.

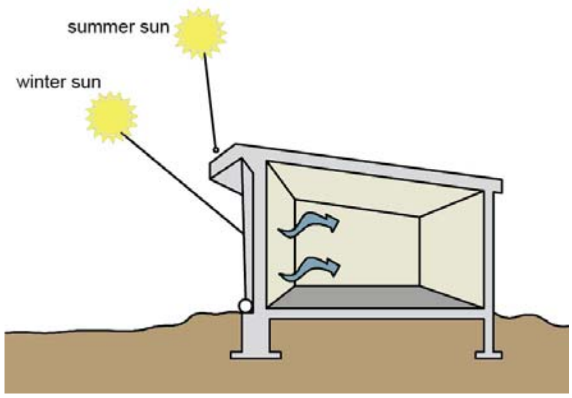

Figure 1. Trombe Wall

- **Roof pond systems**

According to Figures 2, 3, in this method, water storage bags whose capacity is nearly 20 Liters, locate in buildings roof. In winter, antifreeze plays a significant role against freezing. At this period of time, during the daytime, insulation upon the storage bags are pulled off in order to receive and store solar radiations. During the night-time, insulation covering is placed upon the water storage bags, which is definitely, acts as an obstacle against heat transfer to the relatively cold space. At this time, storage heat inside the storage bags is transferred to the interior space via the ceiling. The prosperity of this method is that whereas the covering upon the ceiling acts as thermal heat for heating storage, south facing building is not mandatory. Meanwhile, the drawback of this method is that surrounding buildings should not cast a shadow over each other in the winter, and this method is applicable for one-storey buildings.

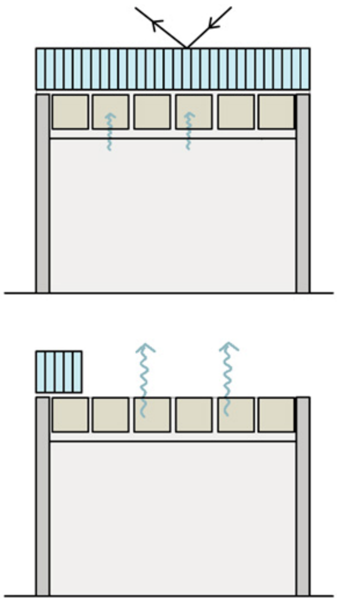

Figure 2. Water storage bags performance during the daytime and night-time, summer

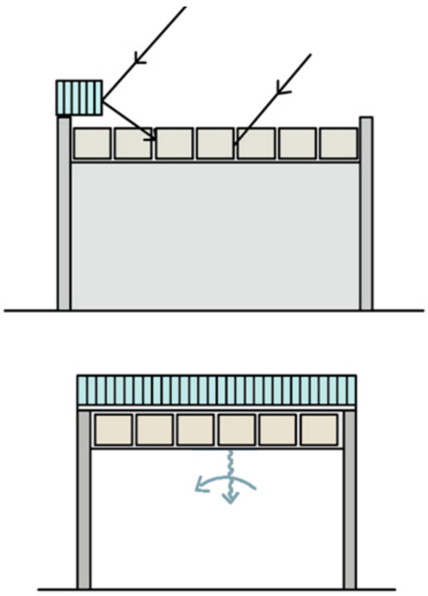

Figure 3. Water storage bags performance during the daytime and night-time, winter

A.3. Isolated Gain

According to Figure 4, in this method, heating storage is via an interface space like sunroom or solar greenhouse which employs a combination of direct gain and indirect gain system features. Glass greenhouse space which is located on the southern sides, receive sunlight during the day, its heat rises gradually and ultimately, is heated greatly. Generated heat in this space is transferred to a stone storage beneath the earth, beneath the greenhouse. There are gridirons inside the storage, which is filled with cobblestone.

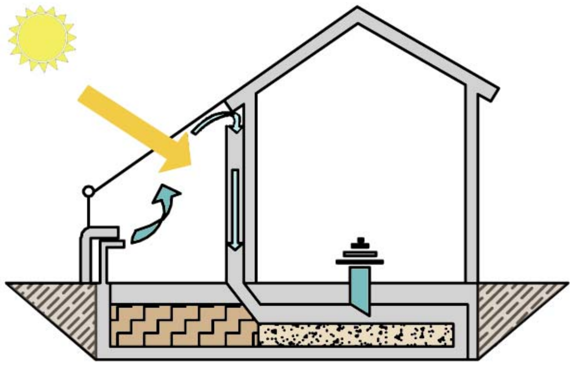

Figure 4. Isolated gain system, storage process

As illustrated in Figure 5, Air circulation is feasible through the grids if the distance between them is about 25 Centimeter. Generated hot air in the greenhouse is transferred to the storage space via fan, then it is stored inside the cobblestone and ultimately makes it's exit via adjustable bar grille and makes the room warmer during the night-time. It should be noted that heat insulation against greenhouse space heat exchange during the night-time is achieved by using thick covering upon the greenhouse glass.

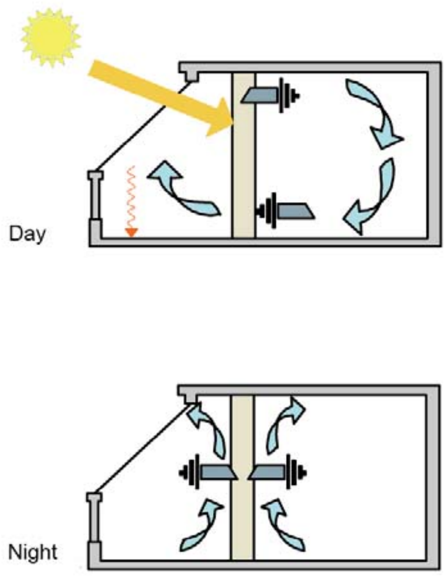

Figure 5. The combination of Trombe Wall of masonry material and greenhouse, the performance in day/night cycle

Sunlight entering the sunroom is retained in the thermal mass and air of the room. Sunlight is brought into the house by means of conduction through a shared mass wall in the rear of the sunroom, or by vents that permit the air between the sunroom and living space to be exchanged by convection.

The use of a south facing air collector to naturally convect air into a storage area is a variation on the active solar system air collector. These are passive collectors. Convective air collectors are located lower than the storage area so that the heated air generated in the collector naturally rises into the storage area and is replaced by return air from the lower cooler section of the storage area. Heat can be released from the storage area either by opening vents that access the storage by mechanical means like fans or by conduction if the storage is built into the house.

The sunroom has some advantages as an isolated gain approach in that it can provide additional usable space to the house and plants can be grown in it quite effectively. The convective air collector by comparison becomes more complex in trying to achieve additional functions from the system. This is a drawback in this area where space heating is less of a concern than in colder regions where the system would be used longer. It is best to use a system that provides more than one function if the system is not an integral part of the building. The sunroom approach will be emphasized in this information since it can provide multiple functions.

B. Passive Solar Cooling: Ventilation and Operable Windows

A primary strategy for cooling buildings without mechanical assistance is called passive cooling in hot humid climates is to employ natural ventilation. In the Austin area, prevailing summer breezes are from the south and southeast. This matches nicely with the increased glazing on the south side needed for passive heating, making it possible to achieve helpful solar gain and ventilation with the following strategies [4]:

- Place operable windows on the south exposure.
- Casement windows offer the best airflow. Awning or hopper windows should be fully opened or air will be directed to ceiling. Awning windows offer the best rain protection and perform better than double hung windows.
- If a room can have windows on only one side, use two widely spaced windows instead of one window.

V. MATERIALS USED IN GREEN ARCHITECTURE

It seems that every other day, some innovative, new sustainable building material for green buildings is introduced. Some are recycled, recyclable, or brought back into use from architectural salvage companies. Others are local materials including those, like adobe, rock and gravel, which can be harvested from the building site itself. Most of these contain few or no toxic substances or finishes, and many, such as bamboo, straw bales, cork, and recycled denim insulation, come from sustainable or low-impact sources [2].

VI. HELP THE ENVIRONMENT BY RECYCLING

Taking a broad definition of recycling as reusing resources this has been one of the most basic human responses to living in the world, and learning to live, survive and indeed thrive by using, and then reusing, the resources we find around us. From the early days of mankind, when our ancestors were hunter-gatherers, evidence from this time shows the resourcefulness of early weaponry - using flints, both for fire and as tips for spears, and then becoming more sophisticated and using the parts of the animal that can't be eaten, the bones, for tools. As hunter-gatherers 5,000 years ago, through to pastoralists, working the land and developing that into modern agriculture, and then through to surviving nomadic groups in the current age, in remote areas of Asia, the African sub-continent, and Arctic regions, reusing resources has always been vital. Traditionally, a wasteful society has always been one that would not survive - greed, coupled with an increase in leisure time would be its downfall. Mankind's innate ability to think, create and design, from early innovations like the wheel, through to the plough, was traditionally based upon using materials from local, immediate sources, like stone, wood, and bone. But, in contrast, mankind's turn toward wastefulness and move toward the easy disposal of resources seems to have begun with the development of weapons of war!

Dr. Nash, Physical Science teacher at Brashier Middle College names a few ideas of why our environment is in danger of extinction: *Erosion and pollution of streams*, *individual creation of excessive waste*, and *overuse of resources*." Recycling is the process of turning used products into raw materials that can be used to make new products. Its purpose is to conserve natural resources and reduce pollution. Recycling reduces energy consumption, since it generally takes less energy to recycle a product than to make a new one. Similarly, recycling causes less pollution than manufacturing a new product, and conserves raw materials. It also decreases the amount of waste sent to landfills or incinerators. Although people have always reused things, recycling as we know it today emerged as part of the modern environmental movement [3].

VII. CONCLUSIONS

Energy efficiency is important not only because of the environmental concerns surrounding energy use, but also one of the important goal of sustainable architecture and zero energy emission as an outcome. As a result, brighter future of the earth, human being and its architecture depends on efficient solar energy consumption in buildings by applying several passive solar design techniques and regarding our environment fastidiously to eliminate or even minimize hazardous consequences.

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BIOGRAPHIES

Fariborz Mahdavi Tabatabaei Fard was born in Tabriz, Iran, 1979. He received the M.Sc. degree from Islamic Azad University, Tabriz Branch, Iran in 2004 and also he has been the Ph.D. student of Azerbaijan University of Architecture and Construction, Baku, Azerbaijan since 2007. Now, He is the Managing Director of Sabat Tarh Company, Tabriz, Iran.

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Fagan G. Aliyev was born in Agjabedi district, Azerbaijan, 1945. He received the B.Sc. in heating, gas supply and ventilation in 1969 from Azerbaijan Technical University, Baku, Azerbaijan. In 1979, he received the Ph.D. degree in technical sciences from Moscow Institute of Construction Physics, Moscow, Russia. In 1981, he received honors degree on the work "Optimization of energy saving in a large Sport Complex in Baku city through automated management and controlling using computer" from Academy of National Economy of USSR, Moscow. Finally, in 1988, he received Prof. Doctor of Technical Sciences from Moscow Institute of Construction Physics, Moscow, Russia. He had special positions like holding lectures and developed courses on HVAC and building energy management and controlling systems in Azerbaijan Architecture and Construction University, Baku, Azerbaijan (1970 up to now), Deputy-Chairman on Construction in Azerbaijan State Sport Committee (1977-1992), Head of Foreign Investment Department at the State Plan Committee of Azerbaijan Republic (1992-1993), Deputy-Chairman of Azerbaijan State Committee for Science and Technology (1993-2000), President of International Ecoenergy Academy (1994 up to now), Expert of UNECE in Republic of Azerbaijan (2010 up to now), Project manager of Alternative and renewable energy sources and its usage in different areas in accordance with the laws and regulations of European Union (2011 up to now). He has several publications since 2001 to 2010, which Reaction of the earth surface's radon field to earthquake, Development of power engineering in Azerbaijan and scientific activities of International Ecoenergy Academy, A unified system of wind-and hydro-electric power stations with hydrogen Accumulation, Hydro-hydrogen pilot project - a new step towards environmental friendly energy development in Azerbaijan, Policy Reforms in Renewable Energy Investments in Azerbaijan, are part of his publications. He had additional relevant activities like Foundation of Scientific-Manufacturing Association "GUNESH" in 1990 and the International Ecoenergy Academy (IEA) in 1994, Leading the IEA's activity, Organizing and holding ten International Baku Congresses "Energy, Ecology, Economy" (1991-2009). Meanwhile, editing 15 volumes of scientific-technical periodical of proceedings of these international forums is his responsibility. Also, he led and participated in the development and implementation of numerous scientific projects in the areas including energy conservation, use of renewable energy resources, environmental problems, recultivation of contaminated soils, preventing atmosphere pollution, etc. In 2005, he was appointed as the director of Hydro-Hydrogen Pilot Project in Azerbaijan for UNIDO-ICHET. He is the Member of Russian Academy of Construction and Architecture and the Member of International Association ABOK as well.