Design by Passive Systems: Passive Solar Design

Ar. Amandeep Kaur[1], Ar. Amrita Shukla[2]
[1] *Department of Architecture, LSAD, L.P.U., Phagwara, Punjab*
[2] *Department of Architecture, LSAD, L.P.U., Phagwara, Punjab*

ABSTRACT

From the beginning, the human needs have been the driving factor in a number of discoveries and inventions. The most significant of these needs are the human comfort and shelter. The designers have been proving us with a number of design alternatives depending upon the requirement of a particular person or a family. But the scenario has changed now-a-days. The designers and the architects are designing the buildings and spaces not only considering the human need but also contemplating on the effect of the building on the environment. It is the environment and the climatic conditions around a space and building which effect the functioning of a building in the end. Thus it is the time to incorporate all those driving factors and parameters into account to fabricate those kinds of buildings which have lower environmental impact and which will help keep the fuel consumption as low as possible. Reflecting upon these decisions, the architects and designers have come to the point of considering the use solar energy in providing the optimum living conditions. The notion of this use is not new as our ancestors used to design with nature.

It is well known fact that the earth receives a vast amount of solar energy every single day. Even a small amount of use of this solar energy can lead to huge differences in the energy demand. Also 25-35% can be reduced in heating component by making fundamental construction improvements. All this leads to the passive solar building design. The aim is to promote the design and construction of energy-efficient, passive solar buildings. The outline of this paper is to provide basic understanding about the passive solar design with possible technical advancements in the field. The technical advancements account both for basic design principles and computerized calculative methods. The essay will also focus on the recent use of the passive systems in the current practices.

Keywords: Passive technology, solar gain, solar design basics, passive solar design, parametric.

1. INTRODUCTION

Passive solar design refers to the use of the sun's energy for the heating and cooling of living spaces. In this approach, the building itself or some element of it takes advantage of natural energy characteristics in materials and air created by exposure to the sun. Buildings can be strategically

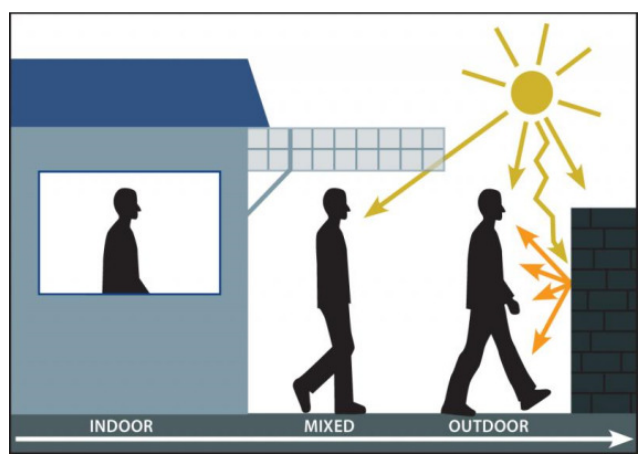
proposed with passive solar features that allow solar energy to contribute to their space heating and cooling demands.

To create a building (cheaper to operate) is to create a system linked to its surroundings akin to:

- relationship between inhabitants and their living zone.
- rediscovery of design skills, knowledge of climate and an awareness of the available technologies.
- human ease contentment and discomfort and how these circumstances can be affected by changes in climate.

Human comfort is defined as the physical and mental well being. Achievement of thermal comfort is important in passive solar building. Regardless of how fuel costs are abridged, the chief rationale of energy consumption for heating and cooling is to keep people comfortable.

Image still: Solar and environmental thermal analysis as related to human thermal comfort. Source: http://www.thermoanalytics.com/system/files/imagecache/content_image_800px/images/thermal_analysis/solar_human_comfort_services_thermal_analysis.jpg



The passive systems of building design depend on climatic factors and thus have two major strategies. For cold climates maximum heat gain, minimum heat loss, sufficient ventilation and for warm climates minimum heat gain (no overheating), cool air ventilation with natural cooling. This should also be considered that the sunlight is available everywhere, but the quantity and quality differs from place to place. Also the sunlight falls perpendicularly in tropical regions and obliquely in high latitudes. As a design approach, passive solar design can take many forms. A basic understanding of the design issues and influencing parameters have a significant effect on the energy performance of a building.

2. BACKGROUND

The techniques of passive solar building design were practiced for thousands of years, by necessity, before the invention of mechanical heating and cooling. Fully developed solar architecture and urban planning methods were first employed by the Greeks and the Chinese who oriented their buildings towards the south to provide light and warmth. Romans bequeathed a fine paradigm for use of glass to heat up the interiors to an accepted level of temperature. E.g. the Roman bathhouses had large south facing windows.

Roman bathhouse. Source: http://www.romanbaths.co.uk/

Cross section of a Roman heliocaminus. The term means "sun furnace." The Romans used the term to describe their south-facing rooms.

Source: http://www.californiasolarcenter.org/

Cities in 18th and 19th centuries were overcrowded and houses were ill-lit. In the 19th century, pioneering urban planners set out to design better conditions. A 19th-century solar remodel: (Image Below) Architect Humphrey Repton turned a dull interior (left view) into a vibrant home by opening up the house to a south-facing greenhouse.

With the advent of mechanical means of heating and cooling there was hardly any interest left in the field of using solar energy. E.g. considering U.K.'s coal supply, there was little interest in using

solar energy to cut fuel costs and bills until recent years. Thus, the recent developments, the facts of fuel depletion and extreme environmental impacts have again necessitated the use of such conservation techniques which will have low environmental impacts. Examples of use of passive system in building design:

1. Wallasey School, Cheshire, 1961

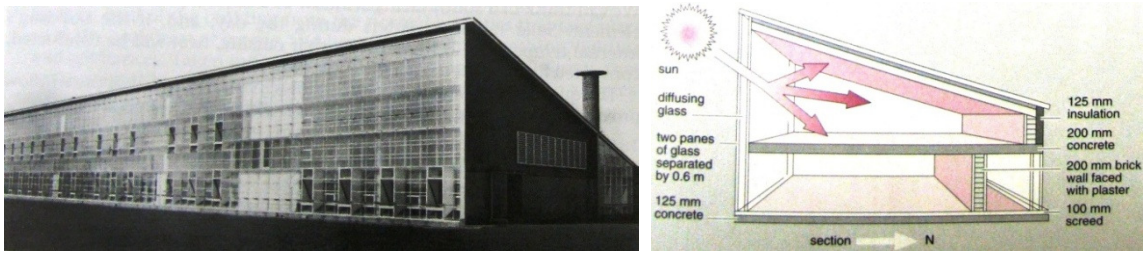


Image source: Book-Renewable energy-Power for a sustainable future. Pg 63

2. Passive solar heated houses in Pennyland, Milton Keynes, 1970's.

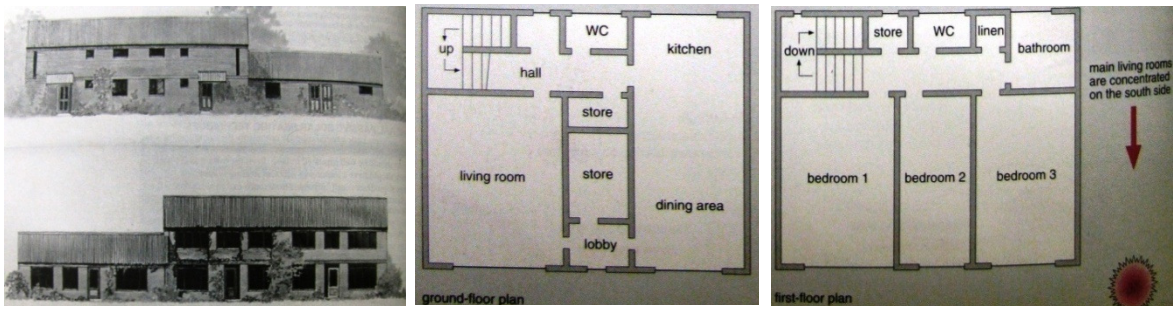


Image source: Book-Renewable energy-Power for a sustainable future. Pg 68

3. WHY PASSIVE TECHNOLOGY?

Passive systems are the concepts and ideas which rely on natural energy i.e., sun and wind. The systems have few or sometimes no mechanical assistance to perform. No use of mechanical aids helps the passive systems to perform efficiently and quietly. The passive solar designs are simple and thus lower the cost of the job and increase the lifetime. On the other hand active solar technology comprises of complex energy consuming equipment e.g. electric water heater, heat pumps, boilers, furnaces, AC etc. A regular window designed passively can be as efficient as active solar systems.

Energy conserving designs have been in practice for quite a lot of time, but there is a difference between the energy conserving design and the energy conscious design. The energy conscious design incorporates passive design ideas and by using solar energy through passive systems. The

main reason that passive makes sense economically is that these systems are durable for a longer time span with little or no maintenance. Passive solar systems save fossil fuels. And since these systems do not require transmission lines, pipelines and the like, they produce neither dangerous wastes nor polluted air and water. Passive solar houses are designed based on some parameters and the design is fully driven by them. But it doesn't mean that the passive houses cannot be aesthetically appealing. They can be as good as conventional ones. One can save energy, save money and still can have a better living environment.

4. COMPUTER SIMULATION TOOLS

Using computer modelling to predict the day-lighting and thermal or energy performance of buildings is becoming increasingly prevalent, particularly with the introduction of Green Star rating tools, where thermal and energy modelling is a conditional requirement.

Good passive solar design depends on the complex interaction of several aspects of a building's design. Computer modelling can help designers deal effectively with the complexity of these passive solar design issues, identify and resolve problems of comfort, building performance and energy use, and analyse and fine-tune the design. This accelerates the design process by quickly identifying problems and opportunities, and narrows the range of practical solutions, saving time and money for both the design team and client.

In general, a building simulation package will contain the following information:

- building description – size, shape, orientation, window type, size and orientation, construction material types and their physical properties (e.g., thermal conductance, density, and reflectance)
- design data – insulation levels, internal gains from lights, small power and occupants, infiltration and ventilation rates, equipment efficiencies and desired temperature set points
- site data – sky information, weather data files

The computer model produces information about the:

- extent of shading and solar access to the site
- climatic conditions using the averaged annual weather data or extreme design conditions
- hourly internal temperatures and comfort conditions
- extent of daylight penetration and likely illuminance levels
- annual, seasonal, monthly, daily or hourly heating and cooling loads
- peak heating and cooling loads
- auxiliary energy consumption. (Document: Passive solar design guidance, 2008, MoE, NZ)

CREM's SYBURB project: dev. Computer aided methods of management for urban systems. JULOTTA- SIMULATION PROGRAMME (KALLBLAD 1986)- JULOTTA developed by department of building science at Lund University requires hourly values of direct and diffuse radiation along with latitude, longitude and building orientation. It also requires the values of shading screens and ground reflectivity.

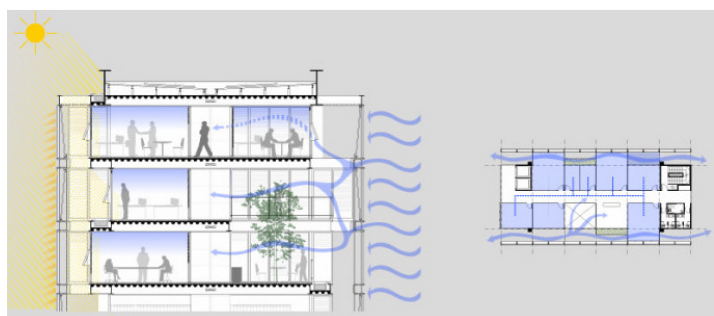
5. PARAMETRIC STUDY METHOD

In parametric studies, the influence of various parameters on indoor temperature, heating and cooling requirements are examined. The main function is to perform a computer based parametric study of the building design solutions and to check the results for energy demands, financial investments, and healthy indoor climate. With the advancement of technologies there are many computer simulation programs available. For example software's like Derob, DYNBIL, energy ten. Project EUFRAT-produce climatic data for active solar systems. That data can also be used for passive systems. Microcomputer programs for such simulations are Zonestead, Netspec, Wallspec, Sunspec and Solrad.

6. CURRENT PRACTICES, TECHNOLOGIES AND PASSIVE SOLAR DESIGN:

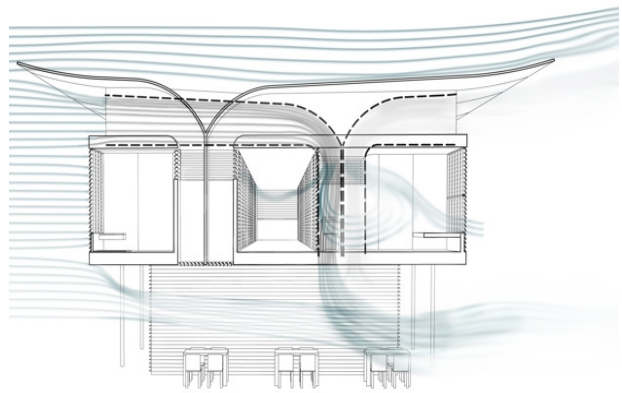
1. Brazilian Office Tower by AUM Arquiteto (Inhabitat.com)

The design not only achieves visual richness in a unpretentious form, but it characterize an outstanding energy-efficient plan as well that amalgamate the appearance and the purpose of the building. The office tower utilizes the sea breezes to cool off and a number of other techniques to avoid running the air conditioners. The building further provides multiple connections to the outdoors. The design strategy focuses on using passive means to cool the building. The screened face on the sides impedes rays of the rising and setting sun. A green roof and projection helps in alleviating mid-day sun exposure. Patios and overhangs at the front of the building scoop up the sea breezes though operable windows. The front and back also have outdoor space which offers views of the sea and forested hillside respectively. The building is topped off with a solar electric array to help offset power consumption.



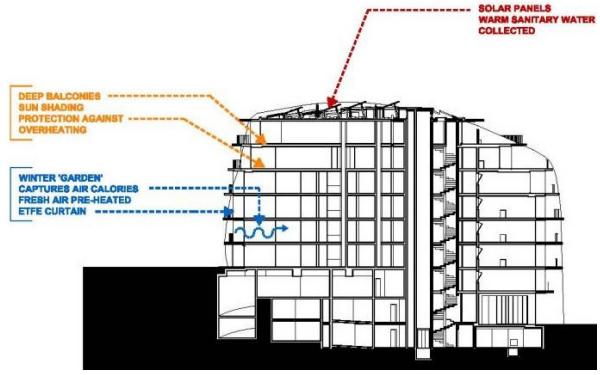
2. Naturally Cooled Bamboo Hostel (Inhabitat.com)

The hostel will be a corporate retreat and training center but the developer also wants to push the limits of green design. The 24 bedrooms are all set on an upper floor which is fed fresh air by an aggressive wind scoop system built into the roof. Designed in conjunction with Arup Engineering, the roof directs the prevailing winds and pushes them into the core of the building, providing each room with cooling breezes. The lower floor will be the community area with a restaurant, conference space and indoor/outdoor area tucked below the sleeping quarters.



4. Passive Solar Parisian Housing Complex (Inhabitat.com)

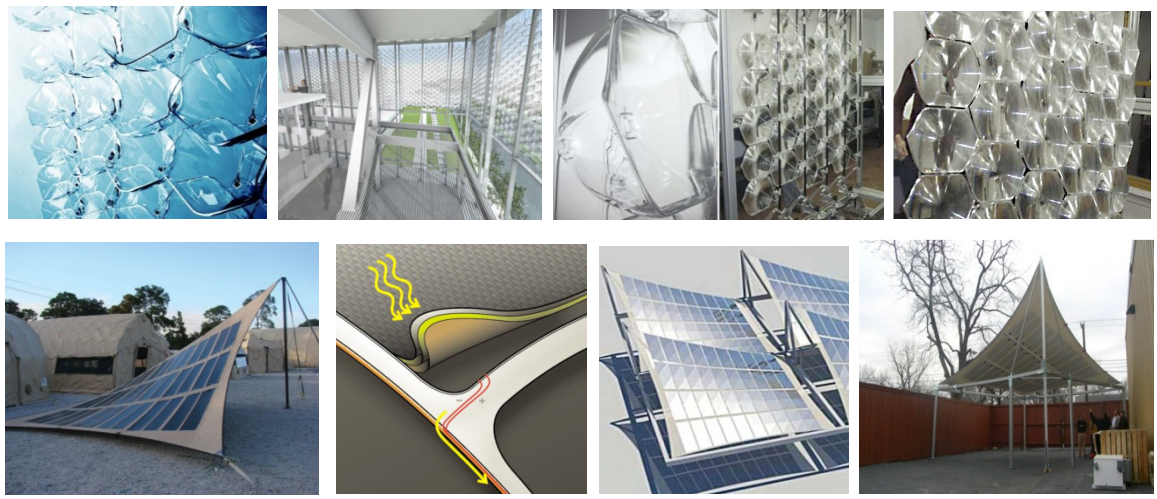
The project was carefully planned to respect the landscape while capturing the sun and adding to the local green-scape. Public and private areas blend seamlessly as the city appears to melt away beneath the preserved trees and breezeways.



7. CASE SOLAR POWER GLASS

The solar power glass system is created of line ups of pyramid-shaped glass receptors. These lined receptors are designed to change their directions according to the movement of the sunlight. The energy thus received is stored in small photo-voltaic cells which are situated in the middle of each

glass pyramid. The transparent design acts as quite an eye-pleasing and attractive system. It means light could pass through the system more effectively for energy storage.



Solar cell fabric (Source: http://inhabitat.com/flexible-lightweight-solar-fabric-by-ftl-solar)

Solar cell fabric consists of integrated thin film solar panels. These panels can shade a deck while providing energy to the house. The fabric was originally designed as easily deployable canopies for military applications; solar products are now available now for solar parking lot shades, rooftop building installations, and small and large solar tent structures. The solar fabric could even act as shading for a sunny deck, and since it's a fabric it's easy to install without any heavy duty mounting hardware.

8. TOWARDS A BETTER FUTURE

Comprehending the basic requirements for passive solar design one can recapitulate the knowledge into the designing a passive heavy and light structured house which should have a high internal thermal storage capacity to decrease variations in temperature and to catch the chill of summer nights by increased ventilation. It should have a white outer surface or a heavily ventilated roof to decrease the heat transfer caused by solar radiation, especially to the roof in the hot season. Other elements like low ventilation rate during winter nights (moderate permanent ventilation in case of light structured house), high ventilation rate during summer night, roof insulation to prevent the solar and night radiation to penetrate the concrete structure should also be reflect upon.

It is evident that typical buildings, designed by integrating passive concepts are able to maintain acceptable room temperatures even in the extreme climatic conditions. Numerous research have been done in the field but an important aspect of future research should be a serious and scientific study of traditional architecture, recognition of the features which are desirable; compilation of

thermal properties of non-commercial building materials. Solar energy is a resource to be taken and used. What needed is the necessary hardware to use it fully and appropriately. We already use solar energy to some extent but with little more care in the building design and their layout, one could make the best use of it.

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