

Passive Construction Techniques: A Review on Residential Buildings of Ludhiana

Ar. Gitanjali Kapoor¹, Ar. Akanksha Sharma²

¹ Department of Architecture, Chandigarh University, Chandigarh, Punjab, India.

² Department of Architecture and Planning, Lovely Professional University, Phagwara, Punjab, India.

Abstract

There are lot of factors in day to day life which effect the environment because of human activities at local and global scale. But among all, construction plays a very important role in damaging the environment right from site clearing, transporting material, construction process to operating the building and recycling it after a period of time. Today along with social and economic issues of urbanisation, the environmental issue also needs a sensitive attention to work on. In rapidly developing countries, economic growth in industrial cities plays a significant role in construction and concentrating population. Industries and energy use in constructions contribute to overall degradation of environment and in raising pollution levels. The cities like Ludhiana are expanding its ecological footprints through carbon dioxide emissions, urbanisation, consumption of land and other human activities and accommodating forests, agriculture, water and other surfaces beyond the city limits. The cities are facing enormous environmental impacts because of rapid construction activities and rapid growth of residential buildings. There is a difference in developing countries and developed countries. In developed countries, the environment is the main consideration as the countries are developed economically, but in developing countries like India, the economic and environmental issues should be taken parallel. Environmental problems of modern cities are: pollution through industrial and construction wastes, water supply and waste, solid waste, air pollution, traffic etc. These problems are mainly in developing countries which are going through economic transition. The underlying causes of leaving the environmental impacts are production of consumption of energy in cooling buildings, industries, traffic etc. But in this paper we are focussing on how the passive construction techniques in cooling building can contribute in protecting the environment and how these techniques can help in improving the environment of Ludhiana which is presently one of the fastest cities of India in construction industry if promoted by the city architects. Buildings usually consume about forty percent of the total energy production in world, which results in producing about forty percent of the nitrogen oxides

and sulphur dioxide that results in causing acid rain and contribute in forming smog. Thus this whole process according to the Institute of World Watch is contributing to the climate changes and leads to accumulating the trapped heat gas. Energies used in buildings also contribute in thirty three percent of all annual carbon dioxide emissions. (Tormenta, 1999) [1].

1.1 Passive Techniques: Extreme climates cause human thermal discomfort, so by cooling the buildings for the occupants can create a better indoor comfort either by electro-mechanical equipments like air conditioners etc. or by making a building energy as well as exergy efficient. The latter simply states that when the energy exchange between the system (building) and the surroundings (environment) comes in an equilibrium state. To create this balance we need to study the various passive construction techniques and their contribution in reducing the environmental impact on cities in the form of heat load and to allow buildings to adapt the local climate and take better advantage of natural energy resources. The energy can be flown by natural ways of conduction, radiation or convection in passive design when the electrical device is not being used. Thus a comfortable environment within a building can be maintained in a hot climate depends on reducing the rate of heat transmission into the building and displacing the excess heat from the building.

1.1.1 Solar Passive Techniques: Passive techniques can be further characterised by 1. Architectural techniques 2. Non-architectural techniques 3. Wetted roof 4. Other passive cooling methods. In architectural techniques the main elements are domed and vaulted roofs, ventilated roofs, high and double roofs. Solar shading like louvers, overhangs, awnings etc., reflective barrier by roof shading and transmittive barriers can be done by providing textured surfaces and by trees and vegetation shading, come under non-architectural techniques. Roof ponds and wetted gunny bags can come under wetted roofs. Other passive cooling methods are insulated roof, green roof, evaporative roof, earthen cooling and solar chimneys like Earth coupling, Passive downdraft evaporative cooling, Desiccant cooling and Roof surface evaporative cooling [2].

1.1.2 General Design Considerations: For passive construction techniques there are few general design considerations which are to be analysed before implementation, like Climatic elements: Temperature, humidity, wind, precipitation, solar radiation and sky conditions, Climate types: hot and dry, hot and humid, composite, cold and Climatic components (temperature, humidity, rainfall, precipitation,

vegetation etc., Climatic design : thermal comfort , ambient temperature , surroundings(form , orientation , vegetation etc.) , psychometric charts , bioclimatic charts , microclimate, solar charts.

3. Review of Literature

A.Ramesh Kumar, KCK. Vijyakumar,PSS.Sinivasan. This review focused on passive cooling techniques through literature study that can be incorporated on residential buildings to make them comfort and cuts electricity expenses. Hot arid country like India consumes enormous amount of electricity to maintain comfortless inside the residential buildings. To meet out the cooling load the energy requisite growing year by year radically. A review on various practices proposed and experiential by the researchers has been done.

Ozturk and Demirel (2004) [3] experimentally investigated the thermal performance of a solar air heater having its flow channel packed with Ranching rings based on the energy and energy analyses. Average daily net energy and exergy efficiencies were found to be 17.51 and 0.91%, respectively. Also, the energy and exergy efficiencies 17 of the packed-bed solar air heater increased as the outlet temperature of heat transfer fluid increased.

4. Ludhiana: Current Scenario

4.1 Introduction: Ludhiana is a prime city of Punjab with sixteen percent contribution to its GDP. Population wise Ludhiana is the largest city of Punjab and in 2009-10GDP its contribution in Indian currency was more than twenty two thousand crores. Ludhiana City is famous for its multifarious industrial base and according to world bank Ludhiana ranked number one in India for doing business. A multi-billion integrated development plan is achieved by this first city of Punjab. Ludhiana is the part of eastern economic and industrial corridor connecting various cities from Punjab to west Bengal . The city supports speedy growth in industries with expeditious transportation of goods and freight. Area of city is more than thirty five hundred sq.kms. with population of 3.5 million with literacy rate 82.20 %. Major industries in Ludhiana are woollens and hosiery, Industrial goods, cycle industry and autoparts manufacturing, food products and beverages, machine parts etc. all at minor, medium and major scale industries. The city is serving a good infrastructure related to road, rail and air connectivity. These above facts about the city's potential of inviting people from less developed cities in search of better economical status , thus increasing the

migration growth in the city for employment. For accommodating less or more people the construction is in boom with affordable housing projects, individual units, apartments and villas etc.

4.2 Infrastructure and Construction development: After agriculture and industrial sectors, the city's major economic sectors are real estate and construction. An integrated industrial park project (aeropolis) has been planned in 1500 acres with IT industries (600 acres), residential development (525 acres), and commercial development. The waterfront city with 2000 acres in outskirts is planned. NH-1 with 6-lane highway is under process with other proposed elevated roads in city connecting most of the cities touching Ludhiana with the proposals agglomerations in future. This shows that city is very much fast in construction and infrastructure projects. During the survey it was found that 500-600 residential plans are being passed by MC three months before [4]. It has been found in Ludhiana city report that 65% pucca houses are there in city. This point needs a sincere attention and can be used as opportunity to promote passive construction practices in city to raise the quality of environment and reducing the overall pollution levels (PPCB report) in operating buildings.

5. Case Studies–Comparative Analysis

S.No	Parameters	Anil Laul's - Single family dwelling.	Residence for Madhu and Anirudh.	Orchid House- Green Residence.
1.	Location	Faridabad, India	Panchkula, India	Magnolia, Texas, US
2.	Climate	Composite	Composite	Humid subtropical
3.	Architect/ Consultants	Ar. Anil Laul	Ar. Anant Mann and Ar. Siddhartha Wig	Environmental associates, architects and consultants
4.	Area	630 sqm	245 sqm	408.7 sqm
5.	Aim of the Project	To create traditional habitat is with courtyard planning. (Fig 2)	To get simple economic viable solutions to respond climatic needs for residential house	Designed to get good quality of indoor air, minimum energy bills and less maintenance.
6.	Planning Features	1. The generation of dome, hyperbolic paraboloid, rotary mode separators with cluster planning have been designed nicely. 2. Use of square proportions to reduce S/V ratio. 3. local stone, following the natural contours of the site	1. It is a GRIHA rating building for passive building techniques and awarded in the 200 buildings registered nationally. 2. The main design feature is its orientation to catch sun in winters and keeping the sun away in summers with courtyard planning.	1. Fully insulated framing for the concrete tile roof with foam and use of ICF's in exterior walls creating exterior envelope for entire house. 2. Passive self-cooled and self-heated greenhouse/solarium is also designed in the house.
7.	Passive Techniques	1. Passive self-cooled and self-heated greenhouse /solarium is also designed in the house.	1. Proper shading has been done with optimum daylighting and specially the solar chimney for ventilation.	1. Water harvesting system and solar photovoltaic panels are integrated in the house. 2. Thermal chimney

		<p>2. A drain all around the house works as natural waterproofing feature. Extensive tree plantation was done on the site and making house comfortable for both seasons.</p>	<p>2. The west wall was insulated to reduce the heat gain. Evaporative cooling and renewable energy systems in the form of solar hot water system and solar photovoltaic systems are the other main design features of this house.</p>	<p>system provides massive passive ventilation cooling for the main house. (Fig 3)</p>
--	--	--	--	--

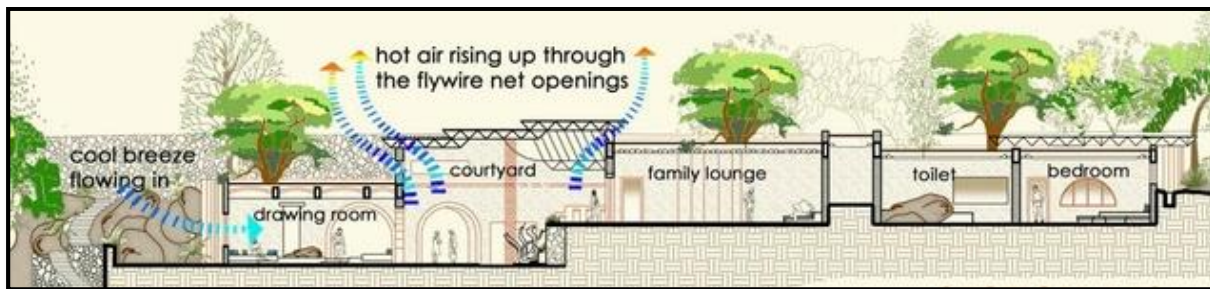


Fig. 2:

Courtyard Planning as Passive Construction Technique in Anil Laul's House

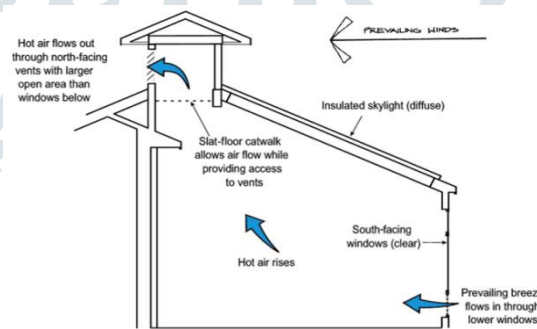


Fig. 3: Solar Chimney as Passive Construction Technique in Orchid House

6. Analysis and Findings

The findings after studying review of literature, case studies and attitude of architects with the help of secondary studies, interviews and through questionnaires are as follows:

a. Meaning of Energy Efficiency in buildings and challenges for architects: After the discussion it was found that maximum architects are aware of passive construction techniques but are unable to promote them due to following reasons: usually less area is available (for courtyard planning), lack of availability of skilled labour (like rat trap bond construction), less variety of energy efficient materials etc [5].

b. Lack of awareness through education system and technical sessions for architects and clients: It is observed that these studies are never a part of education system so it has been advised to provide technical

sessions while developing concepts and making the architects and clients more clear about the positive impacts of these techniques economically and environmentally as well [6].

c. Unavailability of technical software's: There is no optimum software available for evaluating the buildings with and without passive techniques like DEROB in Sri Lanka.

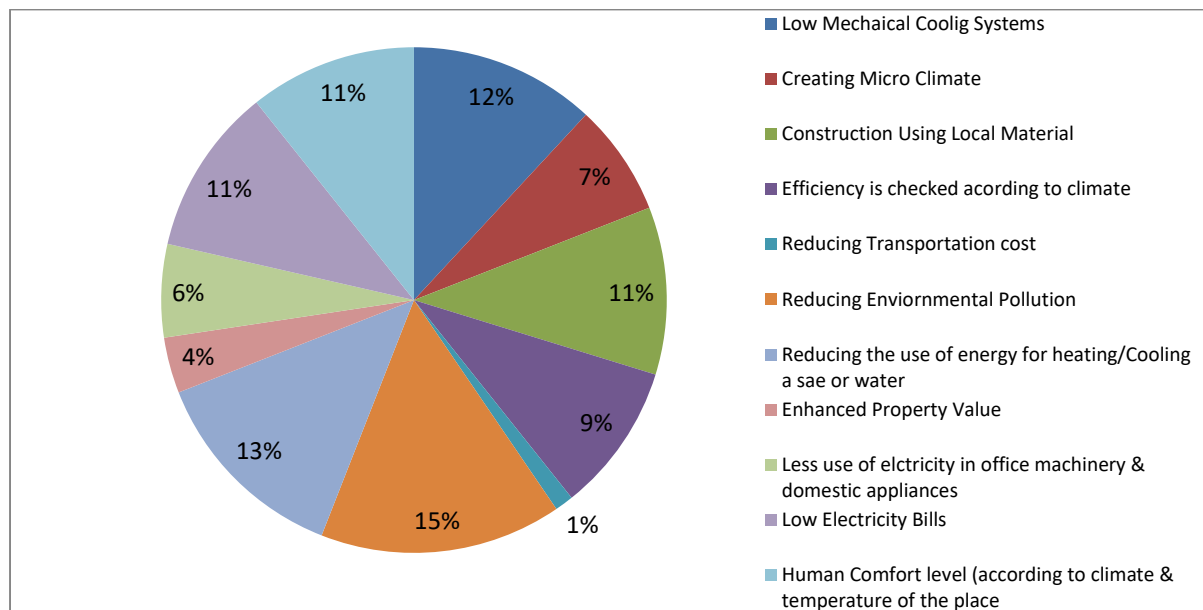


Fig 4. Showing attitude of Architects' for passive construction techniques

d. Clients are least bothered for operational costs of a residential building: The common challenge the architects face is that client only considers the initial construction cost and budget and it is quite challenging task to make them understand [7].

e. Requirement of Govt. policies and Public Participation initiatives: People should consider this as their moral duty to protect environment from overheating and Govt. should invite more innovative construction techniques from international companies and work for more policies other than solar panels.

f. Need of more economic viable solutions: Generally the passive construction techniques are found to be comparatively costlier in smaller areas and possible in only 500-1000 sq.yds. of area, so there is a need to work on more economic viable solutions for implementation.

g. Observations of change in temperature: Double thick brick wall can drop 1.1 °C ,by replacing dark colour with white colour 1.3°C can be dropped and height of roof 1.7°C.

7. Conclusion

Passive techniques need to make the envelope energy efficient and to provide thermal comfort to the humans who are using it. It has been observed that only the residential buildings provide us the

environment where we can relax completely in a stretch. Designing residences with passive techniques can contribute adequately to reduce the heating and pollution levels in Ludhiana city, as it is found to be the leading city with growing townships and agglomerations. The systematic progression of energy consumption with mechanical systems like air conditioners forces a more thoughtful assessment of the urban environment and the impact on buildings as well. With the help of an expanded and enlarged application of passive cooling techniques by the help of architects and experts of other disciplines it can be made a successful endeavour in near future for the integrated improvement of this fastest growing city's environment.

References:

- [1] Census of India. Punjab (2011) District Census Handbook, Ludhiana. Directorate
- [2] Census Operations Retrieved from www.censusindia.gov.in/2011census/dchb/0307_PART_B_DCHB_LUDHIANA.pdf
- [3] K. DO-KYOUNG: The Natural Environment Control System of Korean Traditional Architecture: Comparison with Korean Contemporary Architecture. *Building and Environment*, 41(12), 1905 (2006).
- [4] Ozturk H.H., Demirel Y. (2004). Exergy-based performance analysis of packed-bed solar air heaters. *International Journal of Energy Research*, 28:423–432
- [5] Ramesh Kumar A., Vijyakumar KCK. Sinivasan PSS. (2014). A Review on Passive Cooling Practices in Residential Buildings. *International Journal of Mathematical Sciences and Engineering (IJMSE)*, Volume – 3, Issue – 1
- [6] Tharanga, KC; Mologoda, TN; Rathnayake, RNP; Halwatura, RU. Effect of Passive Techniques In Old Buildings In Sri Lanka. Digital Library of Moratuwa, Retrieved from <http://dl.lib.mrt.ac.lk/handle/123/9542>
- [7] Tormenta L. High Performance Building Guidelines. Department of Design and Construction, New York, USA, 1999.