Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

Sustainable and Environmentally Conscious Design: A Solution to Mitigate Environmental Problems

Ar. Zeba Nisar and Ar. Khurram Ashraf (Head)
Associate Professor
Faculty of Architecture and Planning
Integral University,Lucknow- 226026

Ar. Sana Parveen and Ar. Tariqul Islam
Assistant Professor
Faculty of Architecture and Planning,
Integral University, Lucknow-226026

Abstract— **Buildings as they are designed today are responsible for consumption of enormous amount of energy and other non renewable natural resources with a consequent negative impact on environment. Contemporary buildings rely excessively on high-energy materials like aluminum, glass, cement and steel which consume a lot of thermal energy during their Life Cycle Design which results in overall cost of building. Therefore, the need of the hour for developers as well as architects is to use the available alternatives, and utilize modern technology which saves energy, reduces cost and thereafter reduces building impact on environment. The most reasonable method to overcome this problem lies in the adaptation of sound concept of Sustainable development which promotes Climate Responsive Architecture and Energy efficient Designs. Hence, the urgency of promoting sustainable and environment friendly non-conventional and renewable sources of energy has assumed greater significance in the present time.**

Keywords— ***Sustainability, Sustainable design, energy efficiency, passive building design etc*.**

I. INTRODUCTION

"Solutions to environmental problems will be found once humankind ceases its attempts to dominate nature and, instead, views it as a model. Architects must step forward to lead interdisciplinary teams in this newly reoriented problem-solving."

Kate Nesbitt

The most overwhelming urgent crisis facing mankind globally is the concomitant problems of global warming and climate change. The most reasonable method to overcome this problem lies in the adaptation of concept of Sustainable development. The concept of sustainability has been around for a long time but it came into limelight only after 'oil crisis' in early 1970's through various publications wherein the key issues were over exploitation of natural resources, economic development and environmental constraints which pointed towards the inextricable links between environment and development. The sustainable development ensures that our actions and decisions today do not inhibit the opportunities of future generations. This can be framed in the context of a conscious approach towards environment and resource conservation while designing and proposing plan for built environment. By the medium of this article a brief introduction is being given about the various techniques being employed in field for producing environment friendly design.

II. DEFINING SUSTAINABILITY, SUSTAINABLE DEVELOPMENT AND SUSTAINABLE ARCHITECTURE

A. Sustainability

Sustainability is a vision for the world in which current and future humans are reasonably healthy, socially secured, peaceful and growing; there is economic opportunity for all and life supporting biosphere is restored and sustained for future generations. Therefore, sustainability can be defined as the ability of the society and ecosystem or any such interactive system to function without exhausting key resources and also without adversely affecting the environment.

B. Sustainable Development

As defined by Moughtin, 1996 "*Development that is non damaging to environment and contribute to the city's ability to sustain its social and economic structure.*"

Sustainable Development was first introduced as a global socioeconomic concept during 1970s and was very well defined by Brundtland Commission of the United Nations in 1987 as "the development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs".

'Meeting the Needs of Present'	'Without Compromising the Ability of Future Generations to Meet Their Own Needs'
Satisfying *Economic* needs with access to adequate livelihood for entire human race. ***Social* equality which aims at equal distribution of income and provision of adequate shelter required for human well being** **Environment concerns related to reduction of pollutants, minimizing carbon footprints and creating livable environment without devouring mother earth of natural non-renewable resources**	***Sustainable use of renewable resources* that ensures natural rate of recharge of the used resources** ***Minimizing use or waste of non-renewable resource* and also involving 3R's concept for minimizing waste generation.** ***Keeping within the absorptive capacity of local and global sinks for wastes***

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

C. Sustainable Architecture

Eco-housing, green development, sustainable design– environmentally sound housing has as many names as it has definitions, but the Rocky Mountain Institute, in its "Primer on Sustainable Building", flexibly describes this new kind of architecture as "taking less from the Earth and giving more to people." Sustainable architecture is framed by the larger discussion of sustainability and the pressing economic and political issues of our world. In the broad context, sustainable architecture seeks to minimize the negative environmental impact of buildings by enhancing efficiency and moderation in the use of materials, energy, and development space (1).

D. Need For Sustainable Architecture

Buildings as they are designed today are responsible for consumption of enormous amount of energy and other non renewable natural resources with a consequent negative impact on environment. In India, the residential and commercial sectors consume 25% of the total electricity usage of country which majorly is utilized in buildings as the building design is far from climate responsive considerations or energy efficiency parameters. As per World Watch Institute 40% of the total energy use is dedicated to construction and operation of buildings. Globally in 1990, 31% of the global energy was consumed by residential, commercial and institutional sector and emitted 1900 megatons of carbon in atmosphere which is predicted to increase to 3800 megatons with 38% energy consumption by 2050. Therefore, designing and transforming buildings on the sound concept of *sustainability is essential for the survival of human race* and safety of mother earth.

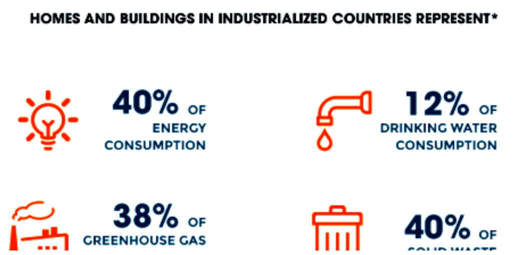

Fig. 1 Source: "Building Design and Construction: Forging Resource Efficiency and Sustainable Development", United Nations Environment Program-Sustainable Buildings and Climate Initiatives (UNEP-SBCI)

E. Principles Of Sustainable Architecture

Sustainable habitat is one which is environmentally benign, economically sound and socially acceptable. Sustainable architecture forms a smart system of relating buildings with the urbanscape comprising of linkages at local, regional and urban level. It is responsible for creating healthy built environment without exhaustive use of available natural resources.

The terms "sustainable, ecological, energy-conscious or environment- conscious architecture", is the only answer to environmental problems. One of the key aspects of sustainability is to harmonize building with the site and its climate which will reduce ecological impacts and achieve energy efficiency keeping in consideration human comfort at most. Climate Responsive Architecture involves Passive Design Systems which use non-mechanical methods to maintain a comfortable indoor temperature and are a key factor in mitigating the impact of buildings on the environment

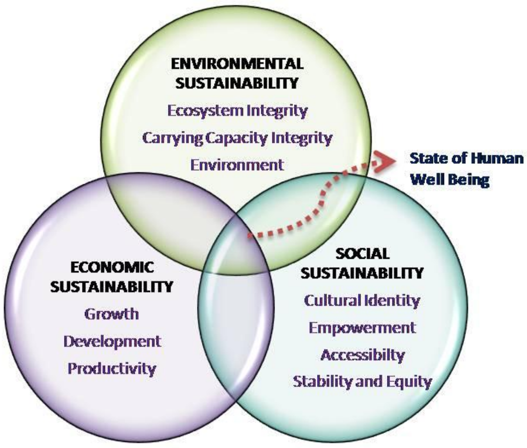

Fig. 2: Principles of Sustainable Architecture

ENVIRONMENTALLY RESPONSIBLE DESIGN PARAMETERS

Use of renewable or recyclable materials which will reduce waste generation and consumption of fresh raw materials

Operational Waste Management

Building performance by use of renewable energy resources like solar energy, geothermal energy usage in

SOCIALLY RESPONSIBLE DESIGN PARAMETERS

End user comfort by creating well ventilated, lighted and healthy space

Urban farming concept to be initiated which encourages people to grow their own eco food

Mixed use Development for reducing transportation and bringing things in approach

Walkable cities for creating lively environment and

ECONOMICALLY RESPONSIBLE DESIGN PARAMETERS

Using passive heating and cooling techniques for reducing energy usage within the building

Flexible design so that buildings are easy to readapt and transform to different uses which will increase building usability

Optimizing resource consumption through usage of

Fig.3: Sustainable Architecture Parameters

III. PASSIVE HEATING AND COOLING TECHNIQUES

In ancient times, passive techniques were the only method employed for cooling buildings while heating was possible through burning of wood or coal. Passive design techniques now days are adopted as hybrid along with mechanical means so as to reduce energy consumption. It helps the building to take advantage of climate when desired and obstruct it when not required. This requires good knowledge of climate on the part of designer

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

A. *Passive Heating Techniques*

Passive heating techniques aim to increase heat gain and reduce heat loss within a space without relying on conventional mechanical means utilizing fossil fuels or electrical energy. The most common passive heating systems are discussed below:

a) *Direct Solar Gain*: Direct solar gain means the heat from sun falling on a surface which can be retained by building's thermal mass and can be used for heating a space. Direct solar gain is the simplest and least costly way of passively heating a building as it can heat a space through the solid walls, roof and fenestrations resulting in heating of interior spaces. Depending on climate, the total direct gain glass should not exceed about 12% of the building floor area. Beyond that, problems with glare or fading of fabrics are likely to occur, and it becomes more difficult to provide enough thermal mass for year-round comfort (2). Direct solar gain is dependent on:

- Thermal Mass: The thermal mass comprises of materials which are capable of storing and retaining thermal gain caused by solar radiation.
- Glazing for Solar Gain: Aperture placement and area is an enormous factor in the amount of heat that is gained, at what times of day, and at what seasons of year.
- Surface color: Dark surfaces absorb more heat as compared to light surfaces which are good in reflection.

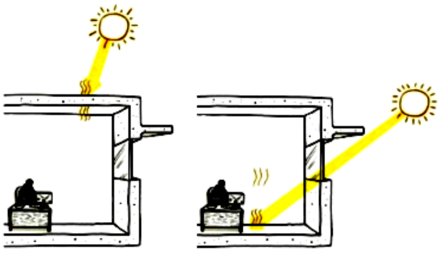

Fig. 4: Direct Solar Gain System;
Source: www.slideshare.net

Examples of Direct Solar Gain

- *Window/Fenestration* plays an important role in any passive heating system and great consideration should be given while designing windows/ fenestrations. They should be capable of providing sufficient light and heat in winters while curtailing same during summers for establishing comfort within a space. In northern hemisphere more windows with proper shading devices should be proposed on southern side to take benefit of solar heat during winters and curtail it during summers.
- *Glazed Atrium:* Atriums are generally provided in the centre of the building and are a climate variant of open courtyard a long practice followed in vernacular architecture. Atriums are generally covered with glazing for the purpose of protection from harsh climate.

Fig. 5: Direct Solar Gain through skylight

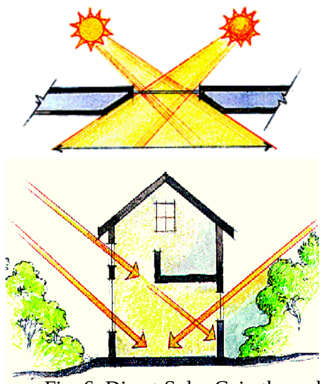

Fig. 6: Direct Solar Gain through splayed walls and clerestorey windows; Source: Greenbuildingadvisor.com

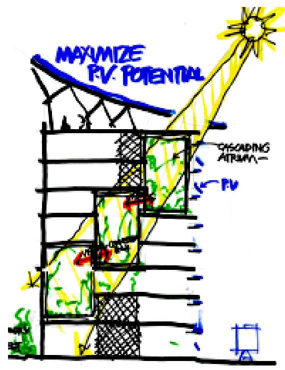

Fig. 7: Direct Solar Gain through Atrium; Source: pininterest..com

Indirect Solar Gain: Indirect solar gain heats a space by positioning thermal mass between the sun and the space to be heated. After passing through glazing the sun's heat is collected and trapped in a space between the fenestration and thermal mass wall though which heat is transmitted to the inner space. This process continues into the space even after the sun has gone depending upon the thermal storage capacity of wall used.

Examples of Indirect Solar Gain

- *Trombe Wall* also referred to as solar wall though patented by Edward M orse in 18 81 was popularized by Felix Trombe in 1964. It is an energy efficient masonry wall designed to absorb heat from the sun during day and radiate it to the inner habitable space for achieving thermal comfort. A typical trombe wall is 20-40cm thick masonry wall painted black provided on south side facing glass opening with a gap of 2-15cm thereby creating a small airspace through which sun's heat is absorbed, stored in the wall and conducted slowly inward through the masonry. The wall has vents on upper and lower side for air circulation.
- *Water Wall* involves the same principle as the thermal mass by intercepting sun rays beyond the collector glazing by a water storage mass which is then converted into heat and distributed by convection and radiation to the inner space. Such systems can not only bring heat into a space, they can be translucent to bring light in as well.
- *Roof Ponds or Thermal Storage Roofs* incorporates a thermal mass (in form of water in bags or a shallow pond of water) on the roof which is exposed to direct sun's heat which it absorbs and stores which it will radiate at uniform low-temperature heat to the entire layout in both sunny and cloudy conditions (3). Moveable insulation is used to expose the thermal mass to radiation in the daytime and to insulate against evening heat losses.

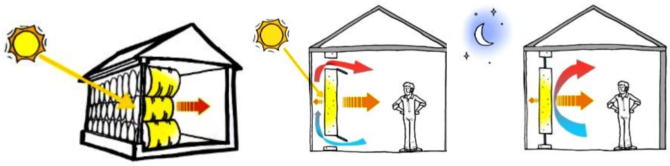

Fig. 8: (a) Water wall and (b)& (c)Trombe Wall;Source: autodesk.com

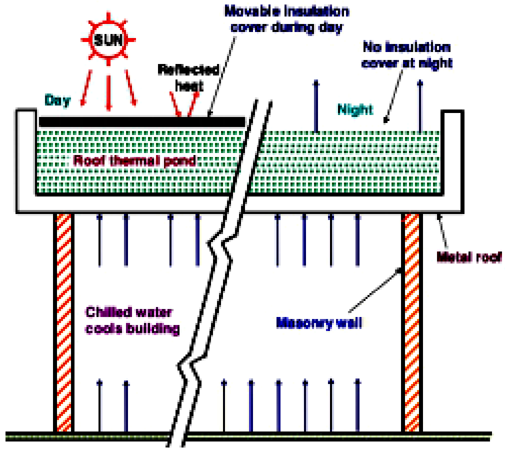

Fig. 9: Roof Pond; Source: slideshare.net

i) *Isolated Solar Gain:* In the isolated gain passive solar concept, solar collection and storage are thermally isolated from the area to be heated. It thus allows collector and storage to function independently of the building (5). It requires a gazed collector space which is both attached yet distinct from the occupied space and must be thermally linked to a solar storage mass for heat retention and later distribution.

Examples of Isolated Solar Gain

✓ Solarium/ Sunspace is similar to a greenhouse , which collects heat throughout the day and disperse it like a furnace in the night. Surface area for solar gain should be maximized with south-facing windows and plenty of well-placed skylights.

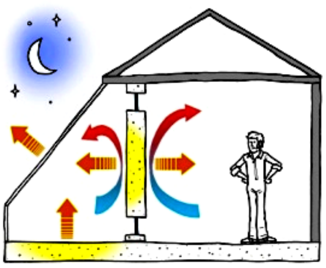

Fig. 10: Solarium; Source: autodesk.com

✓ ThermosiphoSystem includes a collector space (distinct from building structure) in between the direct sun and the area to be heated. In the case of the thermosiphon system, the heat transfer medium can be air or water. A thermosiphon heat flow occurs when a cool air or liquid naturally falls to the lowest point, and once heated by the sun rises up into an appropriately placed living space or storage mass, causing somewhat cooled air or liquid to fall again, so that a continuous heat gathering circulation is begun (4).

B. Passive Cooling Techniques

Passive cooling systems is an energy efficient way of cooling the building without relying on mechanical means and these systems have been used worldwide during historic times of which heritage buildings are existing precedent. Passive system relies on natural heat-sinks to remove heat from the building and cool a space directly through evaporation, convection, and radiation without using any intermediate electrical devices. The most commonly used passive cooling systems are:

a) *Orientation*: Orientation is a significant design consideration mainly with regard to solar radiation and wind which helps in altering and establishing thermal comfort within a building by protecting the building from excessive heating. Therefore, it is mandatory for architects to analyze sun and wind movement before designing spaces. Further, based on the study conducted orientation should be done in such a way that it takes benefits of climatic factors and establish favorable condition within a space (6). As a precedent, in predominantly cold regions such as Shimla, buildings should be oriented to maximize solar gain while in desert areas such as Bikaner the reverse is advisable. Similarly, wind patterns should be studied as the air movement could also be desirable or undesirable. It has been observed that designers sometimes have to compromise between sun and wind orientation for achieving desired comfort level. As an architect one should be careful while designing external shading devices as these devices can be wisely used to exclude the sun and wind and also to divert it. The optimum shape of a building is widely considered to be the one that loses the least amount of heat in winter and accepts the least amount of heat in summer (7).

Climate	**Requirements**	**Purpose**
Hot and dry	Minimize south & west facing walls	To reduce heat gain
Warm & humid	Minimize west facing wall Maximize south and north walls	To reduce heat gain
Composite	Minimize west facing wall Controlled south facing wall	To reduce heat gain For winter heating
Cool Temperate	Moderate area of north & west walls	To receive heat gain
Mediterranean	Minimize west facing wall Moderate area of south walls	To reduce heat gain To allow heat gain
Equatorial Upland	Maximize south and north walls	To reduce heat gain

Fig. 11: Climate responsive requirements;
Source: www.ok.sc.e.titech.ac.jp

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

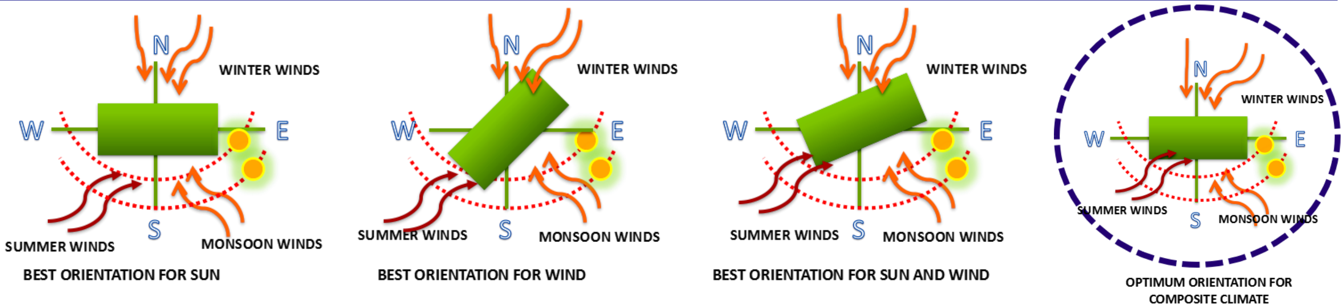

Fig. 12: Building orientation according to sun and wind

b) *Ventilation* provides cooling by carrying away heat from a space through moving air and is one of the most effective way of cooling the indoors. It uses natural sources like wind and buoyancy for delivering fresh air within a space. Air movement inside a building is governed by the temperature difference between the inside and outside as air always moves from high pressure zone to a low pressure zone through openings in building envelope. It involves following mechanisms:

✓ *Wind induced ventilation:* In this case air movement is induced due to pressure difference between the leeward and windward side of the building which causes passive cooling of which wind tower is an example.

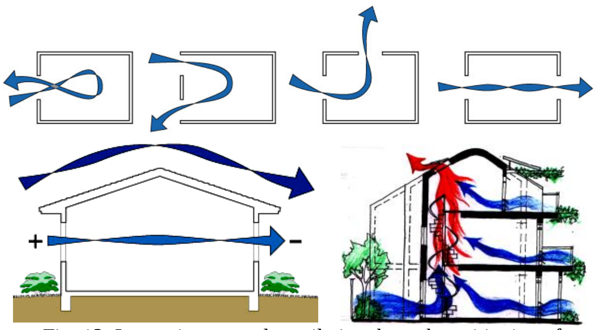

Fig. 13: Improving natural ventilation through positioning of fenestrations (a &b) and stack effect (c);
Source: http://www.efficientwindows.org

✓ *Stack effect:* It is an established fact that warm air rises up and cool air settles down which causes temperature differential inducing a forced upward flow helping in ventilating the space, it is especially beneficial for larger spaces with large flow volumes.

✓ *Solar chimneys:* Solar chimney are stack ventilators that induces natural ventilation by the thermal buoyancy effect and are also called solar ventilators. These are well utilized in areas with low wind speeds and can be combined with evaporative cooling device for establishing more comfort.

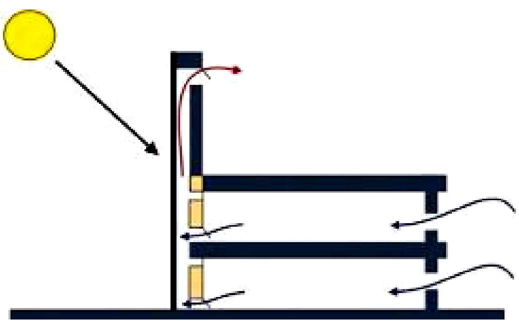

Fig. 14: Solar Chimney; Source: designingbuildings.co.uk

c) *Shading:* Solar shading is one of the most important strategy in passive cooling which partially or completely obstruct sunlight directed towards a building surface by an intervening device or element which serves as a link between daylighting and thermal insulation of peripheral building spaces. This can be done by shading windows, walls and roof from direct solar radiation which can be done in following ways:

✓ *Shading of roof:* During summers the maximum heat gain is through roof surface therefore along with proper insulation shading is required to achieve thermal comfort within the habitable space of which various techniques are shown in Figure 14.

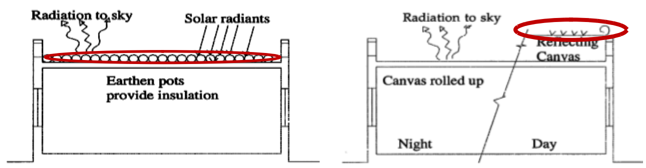

Fig. 15: Roof shading techniques

✓ *Shading of Walls:* Heat gain through walls is again remarkable and need attention while designing and selecting construction materials so as to reduce surface heat gain. Thermally insulated walls provide relief from heat while proper shading of affected walls will add on to the cooling impact. Further, textured walls provide better heat insulation then plane surface walls and reflective paints could be used to create convivial thermal environment within a space.

✓ *Shading of openings:* Windows if well treated will help in reducing heat gain and diffused light will enter into a space thereby making a space habitable and livable. Similarly, louvres are also used to block sunlight and admits desirable daylight inside the building but all this depends on solar orientation of building which is of utmost importance in reduction of heat gain.

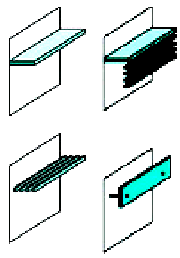

Fig. 16: Shading of windows

- ✓ *Shading through vegetation:* Trees and vegetative covers is considered as an effective way of shading building surfaces against solar heat gain and as per experts shading by trees reduces temperature of ambient air by 5^0 C (8). the selection of trees should be done keeping in mind the orientation of building facade to be treated passively.

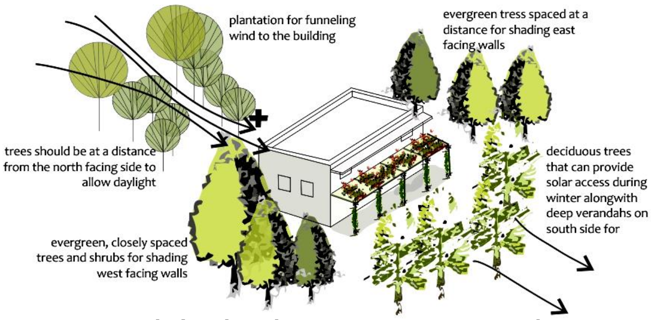

Fig. 17: Shading through vegetation; Source:www.nzeb.in

d) Wind Tower:

Wind tower origin dates back to Egyptian Period preceded by their extensive use in Persian influenced Architecture throughout Middle East especially in regions with hot and dry climate. They were used for inducing natural ventilation within the buildings. The hot ambient air enters into the tower from the top opening and cools down while moving downward into the tower. The cooled air becomes heavy and sinks down. In this case, the adjacent spaces with an inlet on tower side and outlet opening on the other causes a draft of cool air inducing ventilation. In the night the process is reversed as the tower becomes warm till the evening. It has been found out that a 4-5^0C reduction in temperature is experienced over a height of 3 to 4 meters. Further, this system can also be combined with evaporative cooling for achieving better comfort conditions.

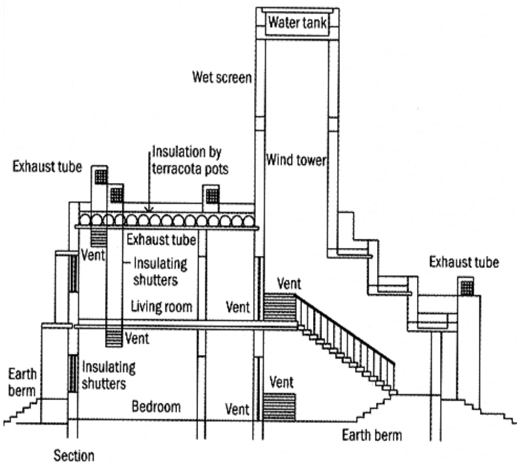

Fig. 18: Wind Tower in Jodhpur Hostel

e) Courtyard Effect:

For centuries courtyards have been used as an effective passive way to respond to climate in regions with hot-dry and warm-humid climate. It was used as a device to cool the spaces during daytime by providing shades to adjacent rooms and as a collector of cool air during night which was supportive in establishing comfort levels within a space along with security and privacy. During daytime, due to incident solar radiation the air in the courtyard becomes warm and rises up causing cool air from the ground level to flow through the room openings causing airflow. During the night, the process is reversed. The courtyard system if efficiently designed may lead to 4-7^0C reduction in temperature during clear night sky conditions.

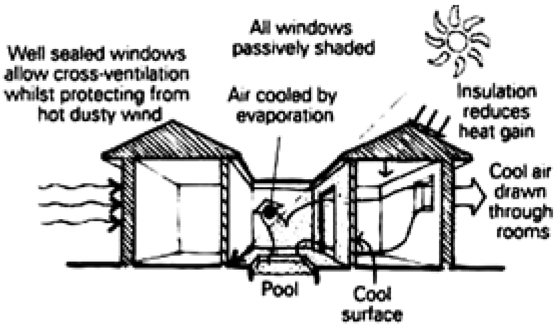

Fig. 19: Courtyard Effect; Source:pininterest.com

f) Earth Air Tunnel:

The Earth Air Tunnel working is based on the fact that the temperature 4 meters below the ground remains constant throughout the year. The EAT are special types of wind towers connected to the underground channel. Through the wind tower opening the wind is channelized to the underground tunnel where it is cooled down and attains the same temperature as the ground temperature. Further, the cooled air is circulated into the habitable spaces for achieving comfortable conditions. During winters, the temperature of tunnel is more than the outside ambient air temperature which leads to heating of the inlet air which helps in heating of the served spaces.

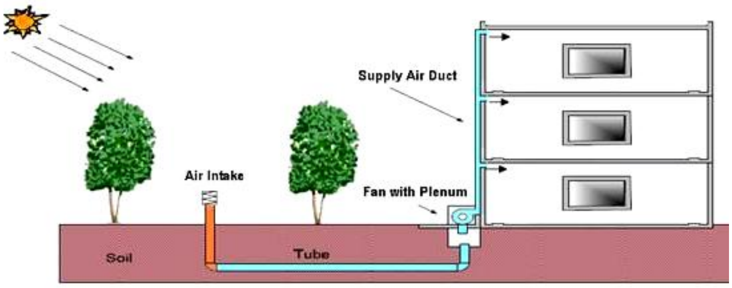

Fig. 20: Earth air tunnel; Source:docplayer.net

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

IV. CONCLUSION

We must begin by taking note of the countries and climates in which homes appropriate for Egypt, another for Spain... one still different for Rome, and so on with lands and countries of varying characteristics. This is because one part of the Earth is directly under the sun's course, another is faraway from it, while another lies midway between these two... It is obvious that designs for homes ought to conform to diversities of climate.

Vitruvius

Globally, it has been visualized that the buildings are designed irrespective of their climate leading to poor indoor climate which demands employment of engineering aids for achieving desirable thermal comfort. The mechanical devices employed for heating and cooling of buildings accounts for 40% world energy consumption which needs to be reduced by employing traditional and vernacular passive techniques. In this article various passive heating and cooling techniques are discussed which should be integrated with design at its evolution stage by the architects keeping in mind the climatic parameters. The incorporation of above discussed passive techniques will definitely help in resolving energy crisis by reducing human dependence on mechanical devices for achieving comfort which will aid in reducing environmental problems caused by excessive energy consumption leading to prolonged sustenance of human race and our planet- 'Earth'.

REFERENCES

[1] Brown, G. Z., & DeKay, M. (2001). Sun, wind & light: Architectural design strategies (2nd ed.). Ney York: John Wiley & Sons Inc.

[2] Cooper, I., & Dawson, B. (1998). Traditional buildings of India.

[3] Das, N. (2006). Courtyards houses of Kolkata: Bioclimatic, typological and socio-cultural study.

[4] Fanger, P. O. (1970). Thermal comfort: Analysis and applications in environmental engineering. Copenhagen: Danish Technical Press.

[5] Gabriel, P., & Garda, D. (1989, Climatic response in a traditional settlement.

[6] Jain, K., & Jain, M. (2000). Architecture of the Indian desert. Ahmedabad: AADI Centre.

[7] Narayan, T. A passive courtyard home in Jaipur, India: Design analysis for thermal comfort in a hot desert climate. Unpublished manuscript.

[8] A. Krishan, N. Baker, S. Yannas & S. V. Szokolay (Eds.), *Climate responsive architecture: A design handbook for energy efficient buildings.* New Delhi: Tata McGraw-Hill Publishing Company Limited. 89

[9] Olgyay, V. (1963). Design with climate: Bioclimatic approach to architectural regionalism. Princeton: Princeton University Press.

[10] Vyas, D. (2005). Traditional Indian architecture- the future solar buildings.

[11] www.pininterest.com

[12] www.nzeb.in

[13] www.efficientwindows.org

[14] www.designbuildings.co.uk

[15] www.greenbuildingadvisor.com

ACKNOWLEDGEMENT

1) wikidwelling.wikia.com
2) www.wbdg.org
3) www.usc.edu
4) www.sensible house.org
5) www.usc.edu
6) www.wikispaces.psu.edu
7) www.odl.teriuniversity.ac.in
8) www.de.scribd.com