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Thermal Comfort in Built Form

Aditya Ambare

***Abstract* – Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment, simply put our body feels at harmony with the climatic condition surrounding us. Our daily life comprises states of activity, fatigue and recovery, and thus it is essential that the mind and body recovers through recreation, rest and sleep to counter balance the mental and physical fatigue and for that we need to have place where we can minimize or eliminate unfavourable factors. The need to achieve thermal comfort in our housing is one of the main factors in a design process and consequences of not achieving it through design increases the cost of using such a building.**

The task of a designer is to create the best possible indoor climate. Criteria of total comfort depend upon each of the human senses. A subjective – emotional relationship with our environment is necessary for survival. Emphasis has to be put on the thermal comfort factors and it is also a dominant problem in tropical climates. Air temperature, humidity, radiation, air movement and other factors have to be taken into account in design process.

The main objectives of thermal comfort, changes as conditions changes. When cold discomfort prevails, objectives are to prevent heat loss and utilise heat gain from sun and internal sources. When hot discomfort conditions prevail, objectives are to prevent heat gain and maximise heat loss. There are physiological objectives that an designer has to achieve in different conditions to make space habitable. Through mechanical methods can help achieve thermal comfort in any kind of building, reducing the effects of nature through design and use of different techniques helps to achieve harmony without disturbing the balance of nature.

Techniques involving passive cooling , dealing with radiation, shading devices, double roof system, surface colouring, thermal massing, ventilation openings, wind tower, air tunnels, trombe wall, landscaping , statically locating water body and more techniques been researched on presently can used in design and help reduce the load on mechanical methods, which can reduce carbon blueprint in buildings. So if we apply such techniques we might see more nature responsive designs.

***Keywords* – Thermal Comfort, Tropical Zone, Indian Climate-Responsive Design, Passive Cooling Techniques, Degree of Comfort.**

I. Introduction

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment, simply put our body feels at harmony with the climatic condition surrounding us. Our daily life comprises states of activity, fatigue and recovery, and thus it is essential that the mind and body recovers through recreation, rest and sleep to counter balance the mental and physical fatigue and for that we need to have place where we can minimize or eliminate unfavourable factors.

India have an extraordinary variety of climatic regions, ranging from tropical in the south to temperate and alpine in the Himalayan North, where elevate regions receive sustained winter snowfall.

Land area in the north of the country has a semi-tropical climate with severe summer. A condition alters with cold winter. In contrast to areas in south where they have tropical climate where warmth is unvarying and rains are frequent.

Majority of Indian populations (fig 2) are settled in subtropical and tropical regions.(fig.1)

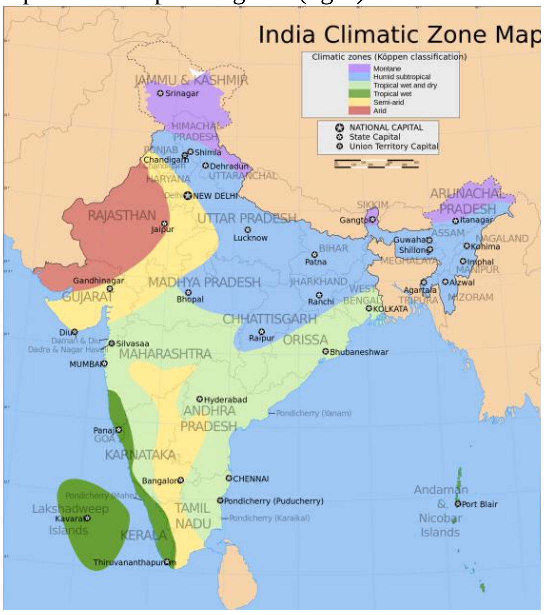

Fig.1. Climatic Zones of India

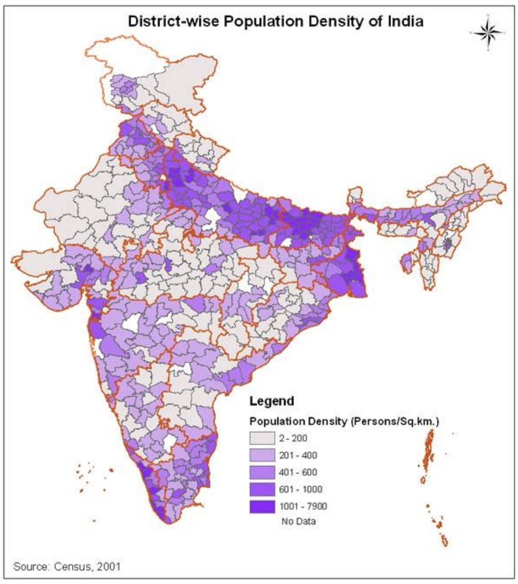

Fig.2. District- wise Population Density of India

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II. Degree of Comfort

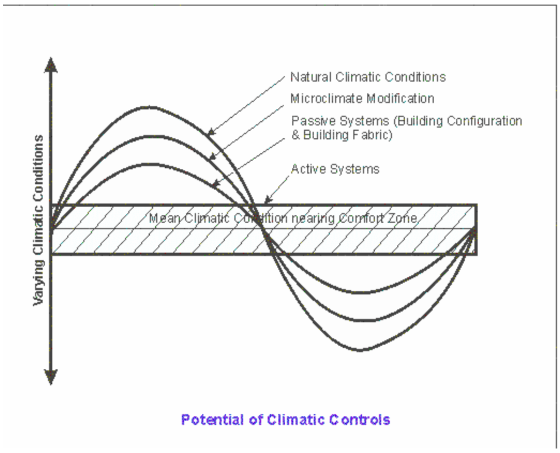

Fig.3. Degree of Comfort index.

Through designing, planning, use of different methods and use of mechanical devices we can create a space in which we can achieve thermal comfort. Under extreme conditions, when human existence is at risk, mechanical controls and positively necessary but when the conditions are such that only the degree of comfort is in question- when the risk is a slight discomfort- use of mechanical controls is optional.

The environment immediately outside and between buildings can be influenced by the design of a settlement and by the grouping of buildings can be influenced by the design of settlements and by the grouping of buildings to a minor extent.

Structural means of control which include design of sun shade device, pergolas, courtyards, and other methods can provide a further levelling out the climatic variations and often comfort conditions can be achieved by such means. Precisely controlled indoor climate can only be achieved by mechanical (active) controls.

As an Architect we can design adequate structural control in order to provide comfortable built space and reduce the load on mechanical controls, thus making it more economical.

III. Trophical Climate

Generally this climatic zone has hot, sticky condition and continuance presence of dampness and air temperature remains 21° and 32°C with little variation between day and night. Humidity is observed to be high during all seasons. Wind direction is constant but slow.

A) Physiological Objectives that we face here:

Heat loss to the air by convection as conduction is negligible because the temperature of the outside air remains almost the same throughout the day and night, a building cannot cool off sufficiently at night time to allow the storage of heat during the day.

Some degree of comfort can be achieved by *encouraging outdoor breezes to pass not only through the building, but across the body surface of the occupants.* There is no significant cooling down at night, the wall and roof surface temperature tend to even out and settle at the small level as the temperature.

B) Design approach –

- As movement of air is the only available relief from climatic stress, therefore vital to indoor comfort, the building will have to be opened up to breezes and orientated to catch whatever air movement there is.
- Open elongated plan shapes with a single row of rooms to allow cross ventilation accessible from open verandahs or galleries.
- Extended plans in a line across the prevailing wind direction afford low resistance to air movement and it therefore the ideal solution
- Door and Window opening should be as large as possible free passage of the air.
- Free from effect of outside obstruction.
- Ventilation- exchange of air is necessary between roof and ceiling in case

C) Airflow and Opening –

- In elation with prevailing breezes to permit natural air flow large fully- open able windows should be used; there is no point in having windows with fixed glass panes.
- Plant cover of the ground tends to create a steeper wind gradient than an open surface i.e. it restricts the movement of air near the ground, thus building on stilts or having habitable rooms on upper floors is also an option.
- Shading of all vertical surface of both openings and solar wall will be beneficial

IV. Sub-Trophical Climate

Broadly these zone are characterised by very hot, dry air and dry ground with day time air temperature being between 27-44 degrees. Humidity is mostly found to be between moderate and low. Little or no cloud cover is observed to reduce the high intensity of direct solar radiation.

A) Physiological Objectives that we face here:

Reduction of the intense radiation.

Low level of humidity results in evaporations which is greater here than in any other climate

Breezes cannot be used to benefit the indoors, unless the air is cooled and dust is filtered out.

B) Design approach –

In order to counter these conditions an enclosed and compactly planned building is most suitable and by placing as much accommodation as possible under one roof, thermal loading from sun and hot air will be considerably lessened.

Surface exposed to the sun should be reduced as much as possible.

Larger dimensions of a building should face North and South as they receive lowest heat load from solar radiation and by aligning buildings closely mutual shading will decrease the heat gains on external walls.

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Non- habitable rooms can be effectively used as thermal barriers if planned and placed on east and west side.

Shading of roofs, walls and outdoor spaces is critical. Projecting roofs, deep veranda, shading devices, trees and utilisation of surrounding wall and buildings can be used in this purpose.

Using low thermal mass for shading devices closed to opening to ensure their quick cooling after sunset.

Construction of 2nd roof over first or a simple ceiling with roof-would be very effective in reducing the effect of thermal gain of roof.

Best external space is courtyard. It is an excellent thermal regulation in many ways and a pool of cool night air can be retained (being heavier than warm air).
High wall cuts off line the sun, and large areas of the inner surface and courtyard floor will be shaded during daytime.

C) Roof, wall and opening

Basic method of utilising the large diurnal temperature variation consist of use of large thermal capacity structures which will absorb much of the heat entering through the outer surface during the daytime, the inner surface temperature would show any appreciable increase.

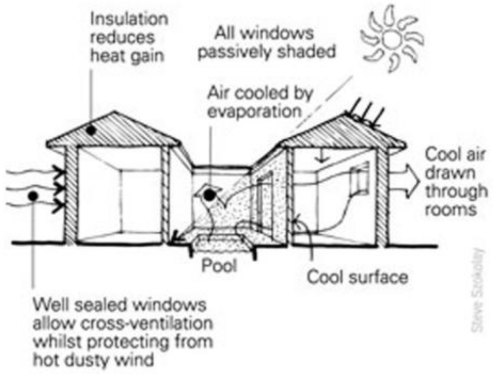

Fig.4. Courtyard Effect on Indoor Condition

D) Ventilation- during day times opening should be closed and shaded. Ventilation will not reduce the radiant heat transfer, but by lowering the temperature of the inside surface of the outer skin, it will reduce the radiant heat emission of that surface.

V. PASSIVE COOLING TECHNIQUES

Above mentioned design approaches need not be enough to create a comfortable indoor environment and passive cooling techniques can be incorporated into the design in order to use natural elements to achieve thermal comfort.

Main objectives that are in focus in these techniques are
1-Exclude unwanted heat gains
2-Generate cooling potential wherever possible
The best way of dealing with unwanted heat gains is to prevent it from reaching building surfaces in the first place.

A) Wind Tower

Wind towers are generally used in hot and dry climates for cooling purposes. A pre-requisite for using a wind tower is that the site should experience winds with a fairly good and consistent velocity. The cardinal principle behind its operation lies in changing the temperature and thereby density of the air in and around the tower. The difference in density creates a draft, pulling air either upwards or downwards through the tower.

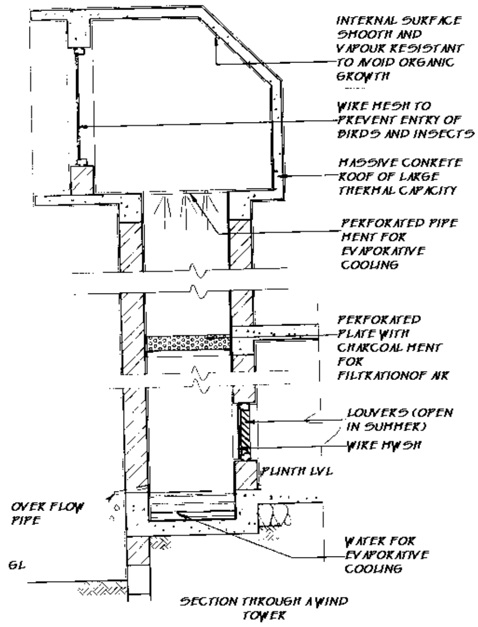

Fig.5. Section of Wind Tower

Variations and controls:

Variations in wind tower design can be achieved by altering tower heights, cross section of the air passages, locations and numbers of openings, and the location of the wind tower with respect to the living space to be cooled. The variations are aimed at providing the desired air-flow rates, heat transfer area and storage capacity. Air flow through different parts of the buildings can be controlled by the doors and the windows.

It may be noted that wind towers are for use only in the summer and must be closed properly in winter.

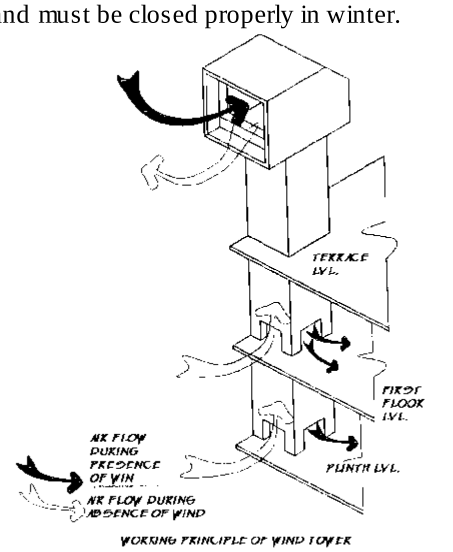

Fig.6. Flow of wind in through Wind tower with respect to indoor areas

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B) Insulation

Any surface that is exposed to high levels of solar radiation in summer should be well insulated to reduce the transfer of heat. The best location for this insulation is on the outside surface; however this may not always be practical. In climates with a high diurnal range in summer (hot days and cold nights), it may be preferable to store daytime heat for release later at night when the temperature falls. In this case, exposed surfaces should comprise a thick layer of heavyweight material with a high thermal capacitance and a thermal lag of around 8-10 hours.

Cavity wall (fig 7) can be used, as the air present serves as insulation. Sometimes these cavities can also be filled with some insulating material for example. Polyurethane foam board etc.

Use of rat-trap bond (fig 8) by proposed by Laurie Baker can also be used.

Fig.7. Cavity Wall

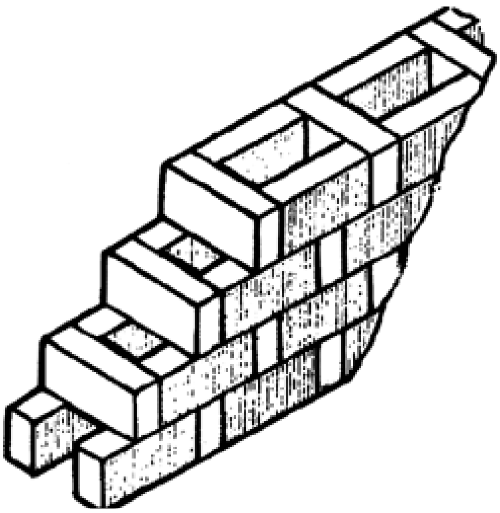

Fig.8. Rat-trap bond

C) Earth Sheltering/Berming

This technique is used both for passive cooling as well as heating of buildings. The earth acts as a massive heat sink. Summer as well as winter variation dies out rapidly with increasing depth from the earth's surface. This temperature at a depth of a few meters remains almost stable throughout the year. Thus, the underground or partially sunk buildings would provide both cooling (in the summer) and heating (in the winter) to the living space. Besides, load fluctuations are reduced by the addition of earth mass to the thermal mass of the building. The infiltration of air from outside is reduced, and there is a decrease in noise and storm effects.

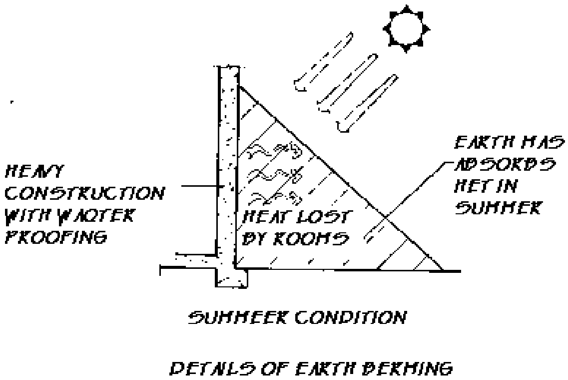

Fig.9. Details of Earth Berming

VI. Conclusion

With the use of these and many more techniques we can attain thermally comfortable zone in many of climatic conditions or none the less minimise the need of mechanical control which will also result in being an economical choice. These approach can assist in providing a major sector of population a thermally comfortable housing which cannot afford the mechanical control devices.

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