Influence Of Passive Techniques on Thermal Performance of Building in Moderate Zone

Minakshi Mishra, Abhishek Deshmukh, K Shanthi Sri

Abstract: Solar passive technologies need to be integrated in Building Designs. This helps not only save energy but also decreases stress and strains in building due to thermal disturbances. The main objective is to achieve comfort for utility for life cycle of the building. Passive techniques are main remedies to increase the building comfort hours without any use of artificial resources. This paper shows the thermal performance of building by simulating different passive techniques before constructing a new building and examines the possible changes that can have influence on comfort inside. A project of proposed building in moderate zone in India at latitude 16.69N and Longitude 74.23E is further examined for manifestations in real time using appropriate simulation tools. The study finalizes that for project under moderate zone, maximum discomfort hours are in summer. Applying the passive techniques to decrease the discomfort hours will finally increase the thermal performance of the building. For Moderate zone, implementation of passive techniques with changes in building material, orientations, air exchanges etc. decrease the discomforts to 9.4% which is 823 hours in a year.

Keywords: Thermal performance, zero energy building, simulation tools, passive techniques, comfort.

I. INTRODUCTION

Energy conservation is one of the most important criteria and also considered as another source of energy in building design. In order to conserve the energy proper designing of the building is necessary. While designing different criteria such as climatological data, building design matrix, thermal performance of the building have been considered to achieve comfort as per standards. A structure can breathe naturally when its thermal performance is good. Thermal performance of a structure directly relates to the occupant's comfort. Implementation of passive techniques will lead to increase in building comfort by natural way.

II. METHODOLOGY

To successfully bring the comfort, passive techniques are the best solutions to solve out the problems by natural way. Passive solar techniques uses natural methods of heat transfer which includes collection, storage, distribution and control of thermal energy flow. Passive techniques influences energy exchange through natural processes by using energy available in the environment. Also, implementation of passive techniques will definitely lead to increase in structural comfort by natural way. Parameters like Building Envelope, Passive Heating, Passive Cooling, Day lighting and Building Materials are the passive techniques used for getting the comfort in the building. In passive techniques passive heating and passive cooling are the most important criteria for different zones. Passive heating is gained successfully by direct gain, indirect gain, thermal storage wall, trombe wall, water wall, trans wall, roof top collector, roof radiation trap, isolated gain, solarium (attached greenhouse/sunspace) methods. Passive cooling is gained successfully by cross ventilation, wind tower, nocturnal cooling, evaporative cooling, earth coupling methods.

III. USE OF ECOTECT SOFTWARE- AS THERMAL SIMULATION TOOL

In order to increase the structural comfort, thermal performance of building has to be calculated. Manual calculation of thermal performance is a very difficult job. So many simulation tools are used for calculating the same. Simulation tools provide the vast information about building thermal performance. The simulation tools which are used regularly are Therm Version 1.0, TADSIM, TRNSYS, DOE-2.1E, Energy Plus, eQUEST, Ecotect Analysis. Among all software, Ecotect is the best suited for the building thermal simulation in India. Ecotect is more user friendly to Indian climatic conditions. Difficulty of input parameters is decreased up to larger extent in the Ecotect . Also the results are more than sufficient for understanding the building performance. Hence thermal simulation can be done using Ecotect software.

IV. THERMAL PERFORMANCE AND COMFORT STANDARDS

As discussed before, building thermal performance is finally calculated in terms of occupant's comfort. The comfort requirements for each zone differ on account of different climate features for all zones. Also, thermal performance of the building varies with change in climatic conditions. Hence for various zones the scope of building thermal simulation applications are different. The thermal performance evaluation of the building with respect to comfort criteria helps us for better choosing of material, architectural design, least use of the artificial resources and money.ISO 7730 defines the comfort condition as: "That conditions of mind which expresses satisfaction with the thermal environment. As per ASHRAE Standard 55(1992), the required temperature ranges for "comfortable" are 73 to 79°F (22.8 to 26.1°C) during summer and 68 to 74.5°F

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(20.0 to 23.6°C) during winter. In order to maintain the thermal comfort, IAQ of the building is
checked as per the ASHRAE standards. ASHRAE standard 62.2 states that warmer indoor temperatures for naturally ventilated buildings during summer can be implemented for achieving thermal comfort and better IAQ.As per ASHRAE Standard 55(1992), indoor humidity levels should always be between 30 percent and 65 percent for optimum comfort. As per ASHRAE standard 62(2003):ventilation (fresh air) should be minimum of 15 to 60 cfm/person based on type of space and ventilation (CO_2) should not be more than 700 ppm in outdoor ambient.

V. Building Model in Consideration with Moderate RegionA project of the residential building in Pune region (moderate zone) is selected for better understanding. Latitude and Longitude of Pune is 18.5^0 N 73.5^0 E respectively. Structure model is 90^0 N offset. Details of residential building taken for the thermal simulation are as follows:

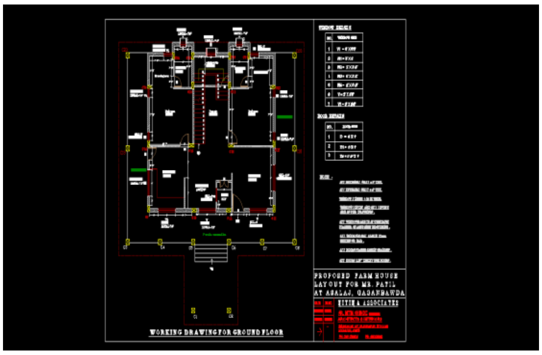


Fig1 Plan View of Building in consideration

Building materials assigned in base case are as follows
Walls: Brick Concrete Block Plaster
Doors: Solid Core Oak Timber
Windows: Single Glazed Al Frame
Floor: concrete floor tile suspended
Ceiling: Suspended concrete ceiling

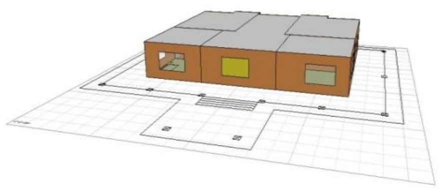


Fig 2 3D View of Building Model in Consideration (Base Case)

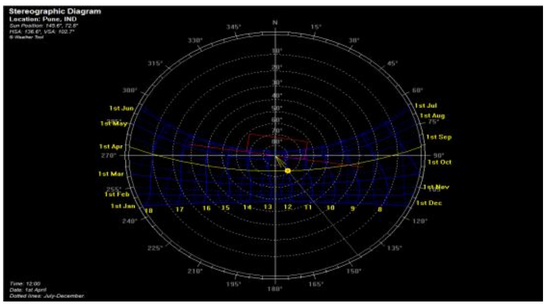


Fig 3 Sun path diagram for Pune region

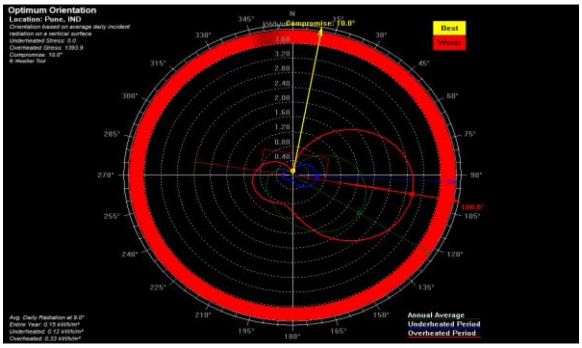


Fig 4Optimum Orientation of Building for Pune Region

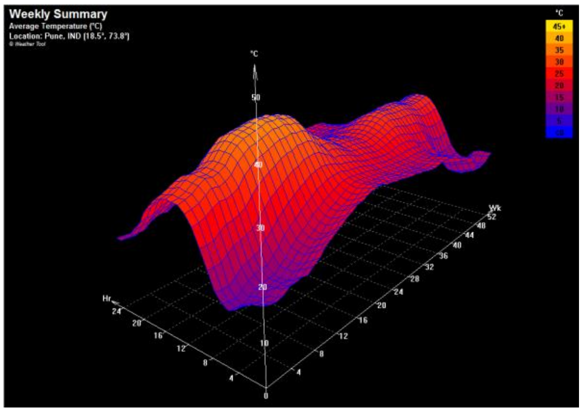


Fig 5Average Temperatures for Pune Region

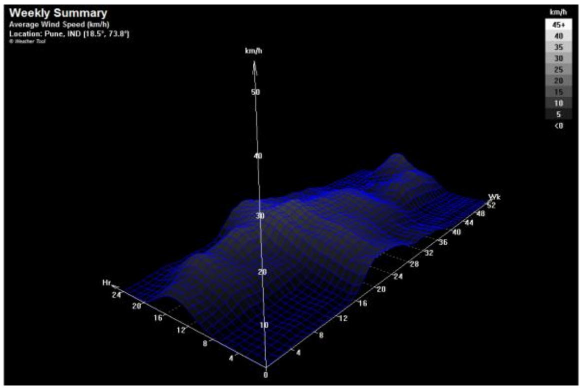
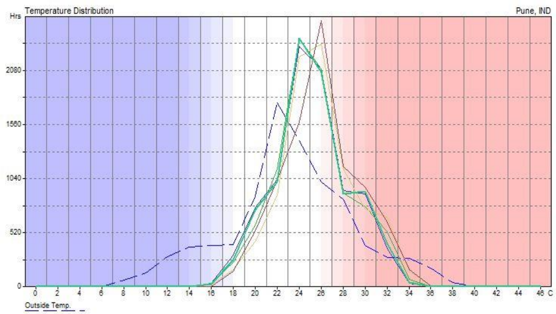
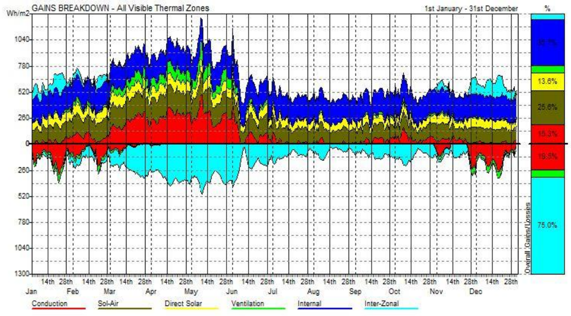


Fig 6Average Wind Speed for Pune Region



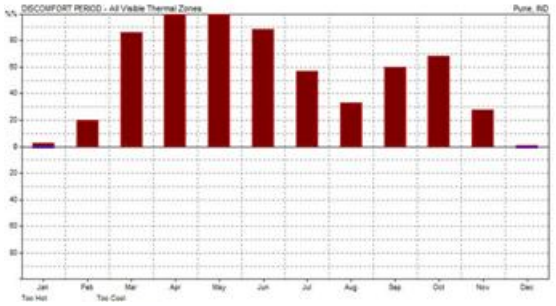
Graph 1 Annual Temperature Distribution Graph showing comfort hours without any application of passive techniques

Significance: Comfort Hours - 6258 hours i.e. 71.43 %



Graph 2 Annual Passive Gain Breakdown Graph with total gain without any application of passive techniques

Significance: Maximum Internal gain and Inter zonal Losses
Minimum Inter zonal gains and ventilation Losses

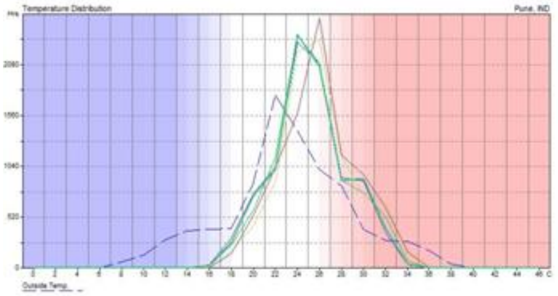


Graph 3 Monthly Load Distribution without any application of passive techniques

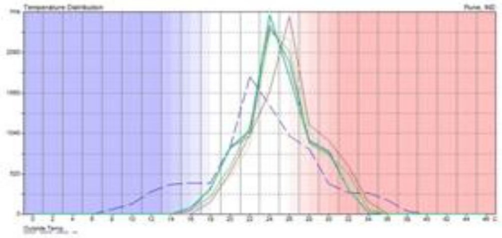
Significance: Maximum cooling required in the month of March, April and May

Application of Passive Techniques:

Change in orientation: North offset 100^0



Graph 4AnnualTemperature Distribution Graph



showing comfort hours after changing building orientation

Significance: The number of Comfort Hours are 6260 hours which is 71.46 % .Hence no significant change is found.

Change in orientation: North offset is taken as 100^0 and Air Exchange Rate is taken as 1.5 ach

Significance: The number of Comfort Hours are 6486 hours which is 74.04 %.

Change in Building Material:

Walls: Double Brick Cavity Plaster
Doors: Solid Core Oak Timber
Windows: Double Glazed Low E Timber Frame
Floor: Conc Slab Timber on Ground
Ceiling: Plaster_ Insulation_ Suspended

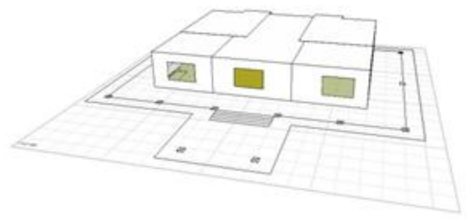
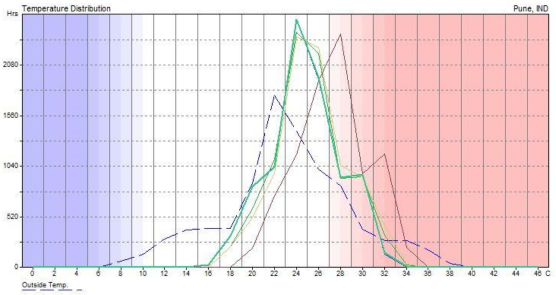


Fig 43D View of Building Model in Consideration after Change in Material



Graph 5 Annual Temperature Distribution Graph showing comfort hours after changing building material

Significance: The number of Comfort Hours are 7081 hours which is 80.83%.

V. RESULTS

Results acquired from thermal simulation tool-Ecotect to understand the thermal performance of a building for moderate zone are as follows: Temperatures in moderate region are not too high not too low. Therefore, temperature moderation to set cooling and heating needs of a building can be sufficiently managed using easy techniques. The building may need methods such as orientation, reflecting glazing, shading and cross ventilation etc. Through these methods, effective reduction in uncomfortable hours can be attained, wherein comfort limits (below 30 ºC) for peak summer months can also be achieved. In this case, heat capacity and thermal resistance of roofs and walls can also be set at moderate levels and high levels not needed.

VI. RECOMMENDATIONS

The main points to be considered while designing buildings in this zone must be
Resist heat gain by:

(a) Reducing the exposed surface area
(b) Growing thermal resistance
(c) Increasing the shading
(d) Growth in surface reflectivity
Promote heat loss by:
(a) Ventilation of appliances
(b) Increasing the air exchange rate (ventilation)

General recommendations:

1. Construction the structure on the windward side is preferable for getting cool Breezes.
2. An open and free layout of the structure is preferred such as lawns or courtyards in order to minimize reflected radiation.
3. With bedrooms on the eastern direction, preferably a north-south direction based orientation can be looked at. West side can be covered while south-southeast side can be used for an open porch. Interiors depth can be ascertained keeping Sunlight exposure in mind. Sufficient isolation should be provided for areas with high probability of Humidity.
4. While a brick wall of 230 m width should be preferred, wall/roof insulation is not required due to limited impact on improving the performance.
5. On account of direction-based properties, size of windows in West and East should be kept smaller, along with South direction. This would help in containing the heat impact. North direction windows can be provided with larger windows. Glazing can be used with low transmissivity. Proper shades (Chajjas) should be provided outside all windows.
6. Except for recessed points (on account of Summer Sun impact), pale colours will be effective.

To decrease the discomfort hours in summer, heat gain should be decreased and heat loss should be promoted. To decrease the heat gain or to eliminate the heat once entered in to the buildings passive cooling techniques may be implemented.

Specific recommendations:

It is found from Hourly Temperature graph that maximum temperature of all rooms exceeds 34 degrees centigrade in a year, indicating acute discomfort. With Summers heat exceeding temperature above comfort levels, cooling may be needed to bring down to comfortable levels of 27 °C to 28 °C.

From all the above graphs, it is found that in the winter months of November to February the rooms are comfortable , and in the monsoon months of July to October. Generally, the house is comfortable throughout the year except in summer from April and May. April is the most uncomfortable month with maximum number of discomfort hours. It is seen that in January, all the rooms are comfortable throughout the day. In April and May, all the rooms are above the comfort zone by about 3 to 4 °C. Hence, it is desirable to have lower air change rates during periods (11 hrs to 17 hrs) when the ambient temperature is higher than the comfort zone, and higher air change rates during remaining hours.

Design Parameters:

1. **Building Orientation:**
   Thermal performance of the building is not changed by change in its orientation. The base case is in fact marginally better.
2. **Glazing Type:**
   A Double Glazed Timber Frame rises the yearly comfortable hours when compared to the Single glazed aluminum frame base case. This type of glazing is therefore useful.
3. **Shading:**
   Decreasing solar radiation by shading windows can subside the heat gain and consequently rise the comfort.
4. **Wall Type:**
   Double Brick Cavity Plaster rises the yearly comfortable hours compared to Brick Concrete Block Plaster (Base Case). A Simple brick wall is much better than other wall types for this region.
5. **Roof Type:**
   Insulating the roof rises performance when compared to a roof with brick-bat-coba waterproofing. However, an uninsulated roof i.e. plain RCC roof reduces the number of comfortable hours.
6. **Color of the external surface:**
   White and cream colors are suitable as compared to dark grey (Inside) Dark Brown (outside) (base case).Significant rise in change of number of comfortable hours due to these colors when compared to the base case.
7. **Air Exchanges:**
   The effects of higher air change rates are very less. As the flow of air rate rises number of comfort hours as compared to the base case 0.5 ach

Operational Parameters:

1. **Internal Gain:**
   Decreasing internal gains rises the performance. Thus, energy efficient lights and equipment should be considered to reduce discomfort.
2. **Scheduling of air exchanges:**
   Scheduling of air changes to promote more air during cooler periods (nights or winters) and controlling it during warmer periods (during daytime or summers) can increase the number of comfortable hours. Combining all the best criteria, one can successfully improve the buildings performance and rise the yearly number of comfortable hours.

VII. CONCLUSION

The thermal performance of the building mainly dependent upon the zone characteristics. The passive techniques help to enhance the thermal performance with respect to comfort to be achieved in the structural envelope. In order to reduce the existing discomfort periods, passive techniques can be implemented such as changing the orientation of the building in turn increasing the air exchange rate increases the comfort hours. By using proper thermal resistance for walls, increasing shading and surface

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reflectivity, heat gain can be decreased and annual comfort hours can be increased.

1. According to ASHRAE, 80 percent of the occupants should be satisfied for 90 percent of the time of the year in a given zone
2. So, all people should be satisfied for 7884 hours in consideration of present building.
3. From the output results of Ecotect analysis comfort hours without any application of passive techniques for building in consideration are 6258 hours i.e. 71.43 % comfort and 28.57% of discomforts.
4. Also, comfort hours after applying passive techniques for building in consideration are 6486 hours i.e. 74.04 % comfort and 25.96 % of discomforts.
5. Also, comfort hours after changing the building material for building in consideration are 7081 hours i.e. 80.83 % comfort and 19.17 % of discomforts

The simulation helps us to find performance of constructions .Considering the passive techniques, it is resulted that the discomforts can be reduced to 2.61% i.e. 228 hours of year in view of ASHRAE techniques. Considering changes in building material with other passive techniques, discomforts reduced to 9.4 % i.e. 823 hours of the year. Therefore it is recommended that Ecotect software helps reducing discomforts.

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