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IDEAL BUILDING DESIGN BY CREATING MICRO CLIMATE

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ABSTRACT

The Vernacular Architecture in India meaning variety of aspects of climate, materials, local craftsmen and utmost comfort. In true sense these designs are energy efficient. But in Modern Architecture majority of time buildings are designed based on passive, mechanical systems to consume more energy. But in comparative analysis they prove how they are energy efficient. But if these buildings are designed by understanding proper sun-path, climate and wind directions; these buildings can be more energy efficient than the former one. This paper is showcasing the different possibilities for building zonings, orientations, and fragmentation of the building foot-print to get more responsive design with respect to climate, sun-path and wind flows along with proper landscape to divert wind flows. If at schematic levels buildings are designed with these strategies energy consumption after building completion is reduced.

There are now different tools and techniques available to guide the designers and users to have a multifaceted approach in building design involving- climate responsive architecture, materials with low embodied energy, reduction of ecological footprint, efficient structural design, recycling and harnessing renewable energy to meet the energy needs of the building etc.

In this paper, form finding is employed as an approach for designing environmental friendly “green rated” buildings integrating energy-related design aspects as one of its main boundary condition. This method is employed in the context of various climatic zones in the country. In order to bring about parity and for standardizing, the same building typology is used throughout the zones. This paper deals with the relation between building form and envelope and its energy consumption in hot dry climatic zone of the country. The purpose of this paper is to provide the guidelines for creating micro climate in any building design focusing mainly on building form and envelope; without using passive techniques for heating and cooling. This design research paper refers to the various primers and manuals that exist for energy efficient buildings in India to arrive at an appropriate building form and then compares it with a base condition. Both considerations for comfort and energy efficiency are accounted for in the building.

KEYWORDS: Sun-path, Wind-flow, Building orientation

1.0 INTRODUCTION

The global environment in future is in danger. So just copying the planning strategies of developed world is unfair. The Indian architects should think of the strategies suiting to Indian climate, economy and society. At the planning stage only, they should think of surrounding, local micro climate, wind flows, sun path, available resources and minimalism. India is preoccupied with its own problems, will hopefully make some serious efforts to put their own house in order to follow reduction in possible energy consumption.

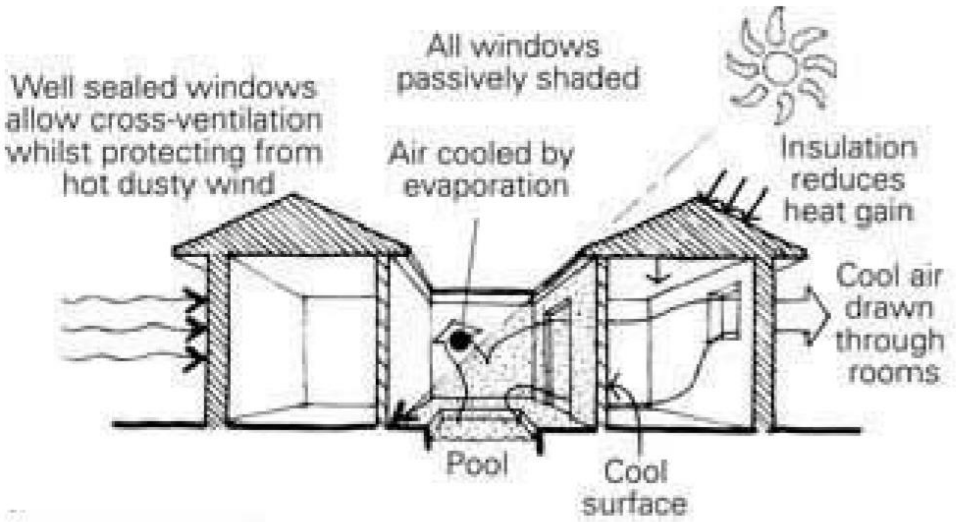
Form finding in Architecture with various boundary conditions has been studied in the past by various researchers. Sigrid et al studied the form generation of high performance based architectural systems driven by solar radiation control and structural efficiency. The façade based systems thus generated explores elastic deformations for shape changes, reducing actuation requirements and could also improve the environmental performance of a building. In another study, daylight uniformity was the factor taken to generate curvilinear ceiling forms algorithmically.

2. FACTORS EFFECTING BUILDING DESIGN AND ENERGY USE TO CREATE MICRO CLIMATE

2.1 FORM

The radiation hitting a building can increase energy requirements for cooling up to 25%. Studies identify the hemispherical shape as the most suitable shape for the building. Other studies have also revealed that H form and L form shapes of the plan as good in terms of energy efficiency. In addition, the presence or absence of a courtyard also helps in lowering the ambient temperature thereby reducing the heat energy inside a building.

Courtyard as the best type of external space in this type of climate as the pool of cool night air can be retained in the inner space as it is cooler and so heavier than the surrounding warm air. If the courtyard is small, where the width is not greater than the height, even breezes will leave such pools of cool air undisturbed. Hence the courtyard is considered as an excellent thermal regulator.



2.2 ORIENTATION

From solar radiation point of view, the best orientation is that which receives maximum solar radiation during winter and receives minimum solar radiation during summer season.

The South façade has advantage of receiving more solar radiation during winter than that of receiving during summer. Even for openings on south facade, small overhang such as curtains can cut off direct solar penetration during summer and allows it during winter. Obviously, this is most beneficial aspect, not available on any other façade. To minimize solar heat gain in south a grassland must be developed.

Orientation of the building is the way the building is placed on the site in alignment to the sun and wind movement (so as to allow or avoid sun/wind). In buildings without insulation and with different shapes, a heating energy saving rate of 1-8% was obtained depending on the orientation of the building.

Solar access' is the term used to describe the amount of useful sunshine striking glass in the living spaces of a home. The desired amount of solar access varies with climate.

Variations in orientation towards east and west can have advantages in some climates and for some activities. For example, in cold climates, orientations west of north increase solar gains in the afternoon when they are most desirable for evening comfort, but east of north can warm the house more in the mornings, improving daytime comfort for those who are at home then. In warmer climates, orientations east of north can allow better capture of cooling breezes.

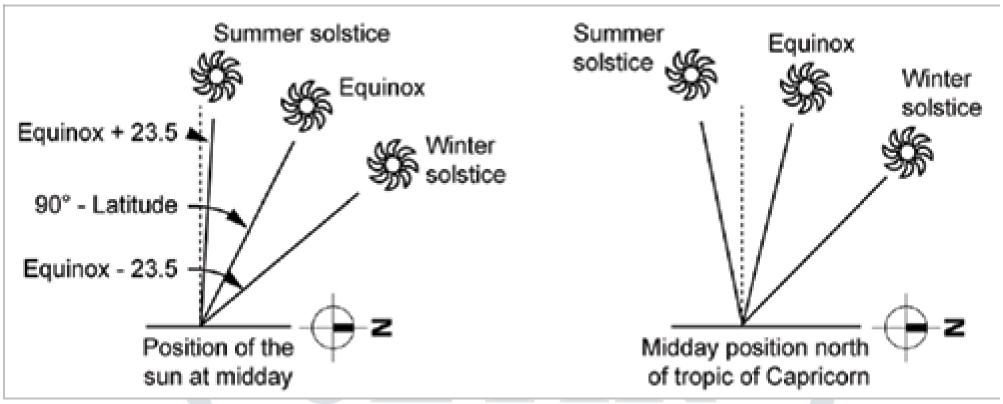
Poor orientation and lack of appropriate shading can exclude winter sun and cause overheating in summer by allowing low angle east or west sun to strike glass surfaces at more direct angles, reducing reflection and increasing solar gains.

Good orientation, combined with other energy efficiency features, can reduce or even eliminate the need for auxiliary heating and cooling, resulting in lower energy bills, reduced greenhouse gas emissions and improved comfort. It takes account of summer and winter variations in the sun's path as well as the direction and type of winds, such as cooling breezes.

Good orientation can help reduce or even eliminate the need for auxiliary heating and cooling, resulting in lower energy bills, reduced greenhouse gas emissions and improved comfort.

Ideally, choose a site or home with good orientation for your climatic and regional conditions and build or renovate to maximize the site's potential for passive heating and passive cooling, adjusting the focus on each to suit the climate. For those sites that are not ideally orientated, there are strategies for overcoming some of the challenges.

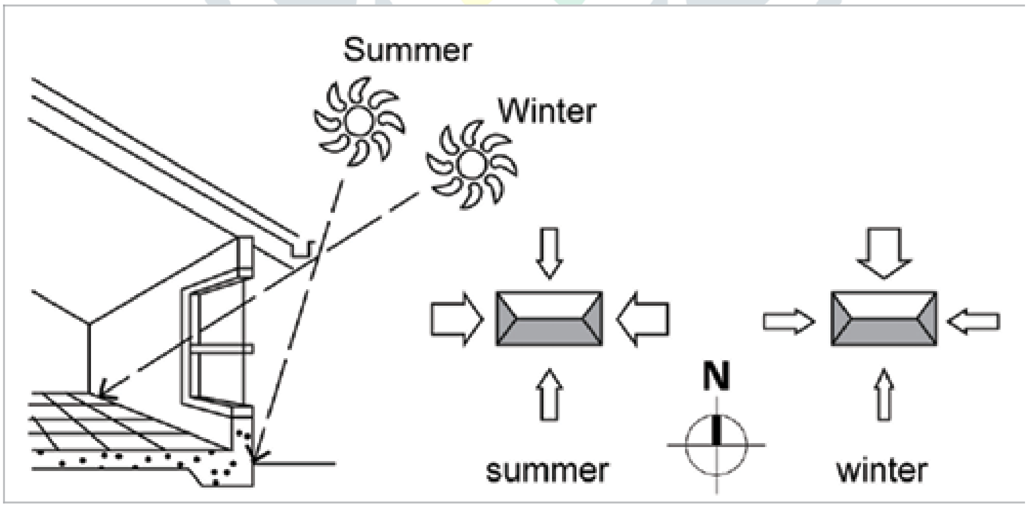
In hot humid climates and hot dry climates with no winter heating requirements, aim to exclude direct sun by using trees and adjoining buildings to shade every façade year round while capturing and funneling cooling breezes.



Left: How to calculate sun angles. (See Shading for a table of latitudes from which to calculate sun angles for Australian cities.) Right: Midday sun position north of the tropic of Capricorn.

North orientation is generally desirable in climates requiring winter heating, because the position of the sun in the sky allows you to easily shade northern façades and the ground near them in summertime with simple horizontal devices such as eaves, while allowing full sun penetration in winter.

North-facing walls and windows receive more solar radiation in winter than in summer. As shown in the diagram, the opposite is true for other directions — and why, in mixed or heating climates, it is beneficial to have the longer walls of a house facing north to minimise exposure to the sun in summer and maximise it in winter.



However, on narrow blocks, careful design is required to ensure sufficient north-facing glass is included for adequate passive solar heating.

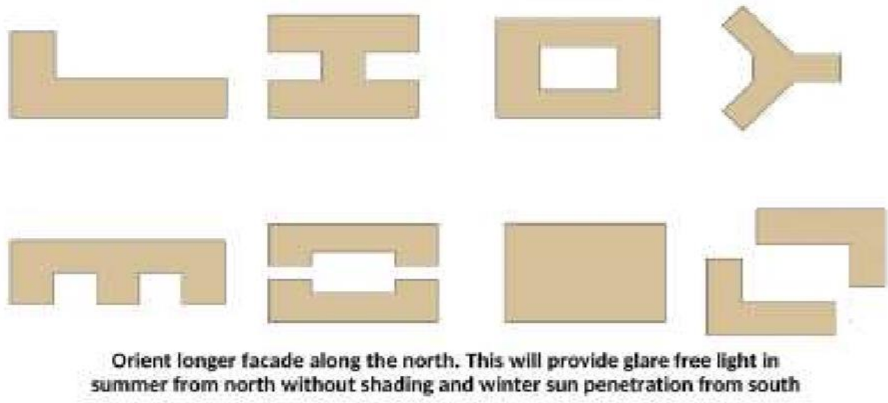


Fig 5: Orientation of longer facades towards north
(Source: http://www.nzeb.in/knowledge-centre/passive-design/form-orientation/)

2.2 VENTILATION

Ventilation, whether mechanical or natural, may be used for:

- Air Quality Control: to control building air quality, by diluting internally-generated air contaminants with cleaner outdoor air,
- Direct Adjective Cooling: to directly cool building interiors by replacing or diluting warm indoor air with cooler outdoor air when conditions are favorable,
- Direct Personal Cooling: to directly cool building occupants by directing cool outdoor air over building occupants at sufficient velocity to enhance convective transport of heat and moisture from the occupants, and
- Indirect Night Cooling: to indirectly cool building interiors by pre-cooling thermally massive components of the building fabric or a thermal storage system with cool nighttime outdoor air.

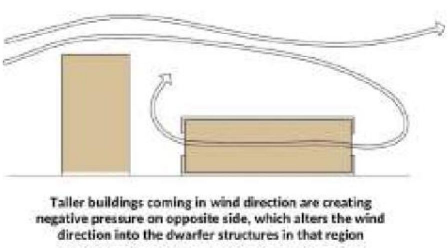
2.3 DAYLIGHTING

Smaller openings that are efficiently shaded. Building with compact internal planning having courtyard, with dense grouping so that the east and west walls are mutually shaded. High-level windows (with a sill above the eye level) or light shelves, which would admit reflected light to the interior. Low-level windows are acceptable if they open towards a shaded and planted courtyard. Vertical strip windows at the corner of the room to avoid excessive brightness and provide a light 'wash' on the walls.

Designing a home in a hot and dry climate takes a very particular approach. Not only do you want the home to be visually appealing inside and out, but it must also be designed to keep cool and conserve the water supply. Most people will live in this climate year-round, so with no escape to greener pastures, you've got to figure out how to make it comfortable under these less than ideal conditions. For hot climates taking advantage of solar PV systems is a good way to conserve energy and use the sun's energy. For best results, you must start from the ground up. That means how the walls are constructed, the design of the plumbing, where the home is positioned on the property and even how you can use the climate to your advantage with green construction.

2.4 BUILDING ENVELOPE DESIGN

Another important criterion is the "Wind Direction." Generally, wind direction for any plot is changing in a day many times. By considering the possible wind directions for the particular plot there are different remedies to follow. In general, when obstacles are coming in the way of wind direction, they cause wind shaded areas on the opposite side of the obstacle. If buildings are becoming the obstacle for wind flow, then they are creating wind shadow regions at the opposite side of the building, causing problems. In this shadow area if dwarfed buildings are placed with proper openings, such dwarfed buildings get surprisingly good cross ventilation as illustrated below in the figure 6.



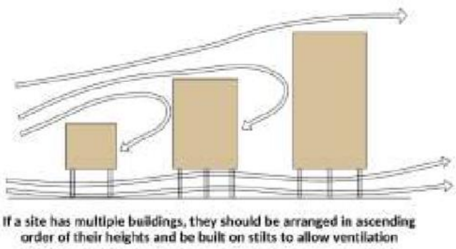


Fig 6: Tall buildings and wind (Source: http://www.nzeb.in/knowledge centre/passive-design/form-orientation)

Fig 7: Variable height buildings and wind flow (Source:http://www.nzeb.in/knowledge-centre/passive-design/form-orientation)

Fig 6: Tall buildings and wind (Source: http://www.nzeb.in/knowledge centre/passive-design/form-orientation)
Fig 7: Variable height buildings and wind flow (Source:http://www.nzeb.in/knowledge- centre/passive-design/form-orientation)

While designing the buildings in big layout we designed variable height buildings. The placement and zoning of the buildings can be decided by understanding wind flow. The building can be stilted and placed in ascending order of heights along the win direction to achieve maximum cross ventilation in all buildings. This is illustrated in figure 7. When the buildings are zoned perpendicular to the wind flow, wind shadow effect occurs at the opposite side of buildings creating uncomfortable conditions. To overcome these buildings can be placed in angular way i.e. to an angle of 30 or 45 degree to get ample wind flow and cross ventilation (figure 8).
Even the buildings can be staggered to divert the wind flow within the buildings (figure 9).

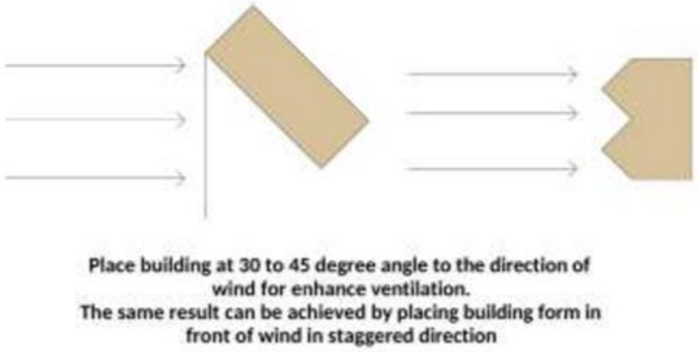


Fig 8: Angular placement of buildings and wind flow (Source: http://www.nzeb.in/knowledge-centre/passive-design/form-orientation/)

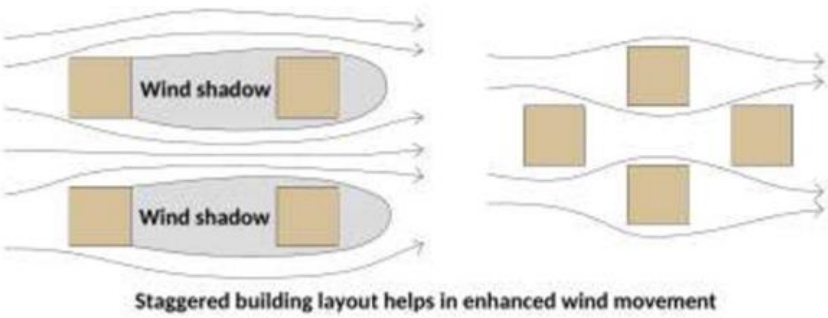


Fig 9: wind flow and staggered buildings (Source: http://www.nzeb.in/knowledge-centre/passive-design/form-orientation/)

Fig 9: wind flow and staggered buildings (Source: http://www.nzeb.in/knowledge-centre/passivedesign/form-orientation/) Many times as per the microclimate site gets good wind flow. But if it is not captured well it just blows around the building but cannot flow inside the building if it is not managed well in design. The following example illustrates how wind can be forced to flow inside the building with proper openings and plantation of trees. The fragmentation of building or staggering the rooms give ample cross ventilation and even enhance the aesthetics of the building. This is achieved by providing tree plantation at require places. Due to desirable cross ventilation the

comfort level of the building is as well enhance and additional sources for mechanical ventilation can be omitted. (Fig. 10)
Fig 10: wind flow and Design (Source: http://www.yourhome.gov.au/passive-design/orientation)

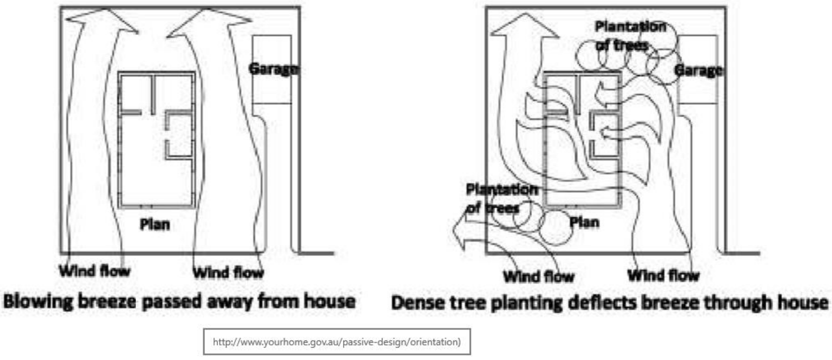


Fig 10: wind flow and Design (Source: http://www.yourhome.gov.au/passive-design/orientation)

2.5 SHADING

The following design recommendations generally shall be followed:

Study of the sun angles is important for designing the shading devices. An understanding of sun angles is critical to various aspects of design including determining basic building orientation and selecting shading devices.

· Fixed shading devices, using correctly sized overhangs or porches, or design the building to be “selfshading” should be installed. Fixed shading dev ices, which are designed I o a building, will shade windows throughout the solar cycle. Permanent sun shades may be built into the building form. They are most effective on the south-facing windows. Awnings that can be extended or removed can also be considered for shading the windows. The depth and position of fixed shading devices must be carefully engineered to allow the sun to penetrate only during predetermined times of the year. In the winter, overhangs allow the low winter sun to enter south facing windows. In the summer, the overhangs block the higher sun.

· Limit east/west glass. Glass on these exposures is harder to shade from the eastern morning sun or western evening sun. Vertical or egg-crate fixed shading works well if the shading projections are fairly deep or close together; however, these may limit views. The use of landscaping can also be considered to shade east and west exposures. North-facing glass receives little direct solar gain, but does provide diffuse daylight.

· In hot and dry climates, the movable blinds help to reduce the convective heat gain caused by the hot ambient air. In warm and humid climates where the airflow is desirable, they impede ventilation. In composite climates, the light colored/reflective blinds block the solar radiation effectively.

3.0 RECOMMENDATIONS

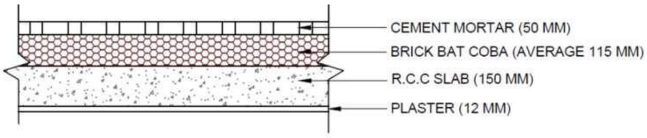
I. Building orientation changing the orientation of the building with respect to the base case does not affect its thermal performance.

II. Glazing type, A single pane reflective coated glass increases the yearly comfortable hours by 10.3% compared to plain glass (base case). This type of glazing is, therefore, recommended.

III. Shading Reduction in solar radiation by shading windows can reduce the heat gain and consequently increase the comfort. An increase of 12.6% in the number of comfortable hours can be achieved, if windows are shaded by 50% throughout the year.

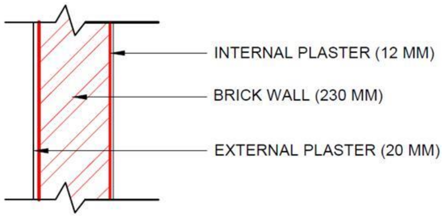
IV. Wall type A concrete block wall increases the yearly comfortable hours by 2.8% compared to the brick wall (base case). However, wall insulation is not recommended.

Roof type Insulating the roof using polyurethane foam insulation (PUF) increases performance by 2.2% as compared to a roof with brick -bat-coba waterproofing. However, an uninsulated roof i.e. plain RCC roof having a higher U-value decreases the n umber of comfortable hours by about 16.8%



ROOF

V.Colour of the external surface White and cream colours are desirable compared to puff shade (base case) or dark grey. The percentage increases in comfortable hours compared to the base case are 4 .8 and 3.0 respectively.



WALL

4.0 CONCLUSIONS

In developing country like India, the architectural designs can be made very sensible at planning stage only by understanding sun path, micro climate of the site, wind directions, locally available material and vernacular aspects like culture, social and economic impacts of the society, to conserve energy for every development. How much energy is being saved in such cases? Further research can be done to calculate amount of energy saved with comparative analysis of various methods adopted for mechanical ventilation. However, having a courtyard arrangement of living spaces also brings down the internal gain considerably. The roofs are the most important building element that helps the building gain less heat and lose more in such climates. Hence the material selection of the roofs and the shading property has to be given utmost priority. Selective shading during day time and its removal during night time also helps in lower heat absorption and faster heat radiation. Moveable shades that are operated during summer and rolled back in winters also help in permitting the sun rays which are desirable in the winter.

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