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CLIMATE RESPONSIVE FENESTRATION FOR RESIDENTIAL BUILDINGS IN PUDUCHERRY WITH WARM HUMID CLIMATE

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ABSTRACT

Energy crisis is the major problem in India especially in Tamil Nadu, measures have already been taken in improving efficiency of appliances by star rating but that doesn't contribute more to the energy scarcity. Building sector consumes large amount of energy when compared to other energy consuming sectors. LEED (Leadership in Energy and Environmental Design) ratings and green building concepts have been introduced to reduce the embodied energy of buildings. In order to reduce the maintenance cost and effective use of power recourses, BMS (Building Management System) of smart buildings and intelligent buildings are used but these are applied only for few commercial projects. As per international energy association in India, 29% of energy is consumed by buildings out of which 21% is by residential buildings and 8% is by commercial buildings, hence if we apply energy conservation techniques on residential buildings in place of commercial buildings it will contribute more to reduce the energy scarcity. This paper majorly focuses on climate responsive techniques of residential buildings to reduce the energy consumption and the effective usage of natural recourses. At the conclusion, the authors specify that ventilation and lighting are the major energy consuming factors of residential buildings which are directly related to the fenestrations of a residential building and for which an appropriate climate responsive fenestration would be the solution.

KEYWORDS: Climate Responsive, Energy Efficiency, Fenestration and Residential Buildings

INTRODUCTION

The fundamental objective of a building is shelter, which is to protect the human from ambient environment and climate. Fenestration is an aperture of the building which opens on to the environment and regulates the climatic factors for human comfort.No other building component has such a significant impact on the design of exterior form, perception of space, relation to exterior space, building performance and appearance. The shape, the character, and the construction of a window has an enormous effect not only on how it looks, as well as how it works. After the invention of air conditioner in 1902 by American inventor Willis Carrier it went under many transformations and spread worldwide, slowly the design of windows specific to climate has been lost. This research paper analyses the different types of windows based on the climatic characters of warm humid climate and also identifies a perfect window or the design aids for a perfect window.

TOPIC DEFINITION

Climate responsive fenestration for residential buildings in Puducherry with warm humid climate.

Technique	Climate responsive (passive)
Design	Fenestration
Typology	Residential
Climate	Warm humid climate
Location	Puducherry, India

IMPORTANCE OF THE TOPIC IN PRESENT CONTEXT (INDIA)

Energy consumption in buildings (With 9% GDP Growth) offers a large scope for improving efficiency. The potential to reduce energy consumption through improvement in the efficiency of appliances and equipment is already accounted. Apart from this, buildings can be made more energy efficient by designs that reduce the need for lighting, heating, ventilation and air conditioning. As per 2011 Planning Commission report, residential and commercial buildings together account for about 29% of the total electricity consumption in India, and is rising at a rate of 8% annually. Approximately, 75-80% of energy consumption in these buildings can be attributed to building envelopes, which include walls, roofs and fenestration. This explains that significant amount of energy can be saved by improving the performance of the building envelopes.

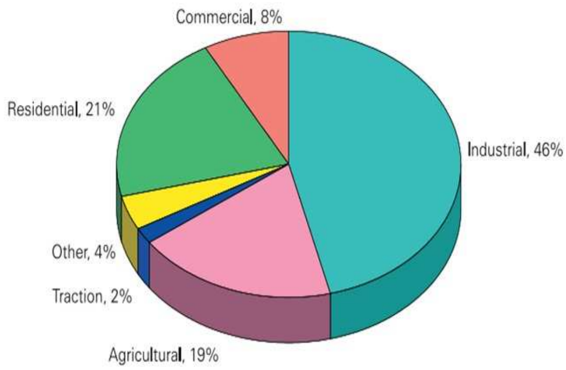


Figure 1: Primary Electricity Consumption in India

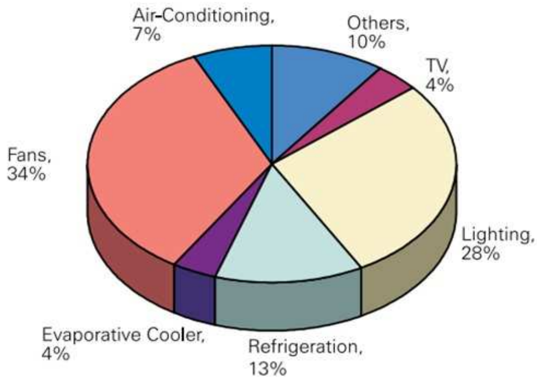


Figure 2: Energy Consumption Distribution in Residential Buildings

Windows are the weakest point of the envelope which allows or restricts the environmental factors, hence a proper design of fenestration is required at the present. Considering the future building sectors, as shown in the Figure 3, climate responsive fenestration for residence would do more to the energy efficiency and sustainability.

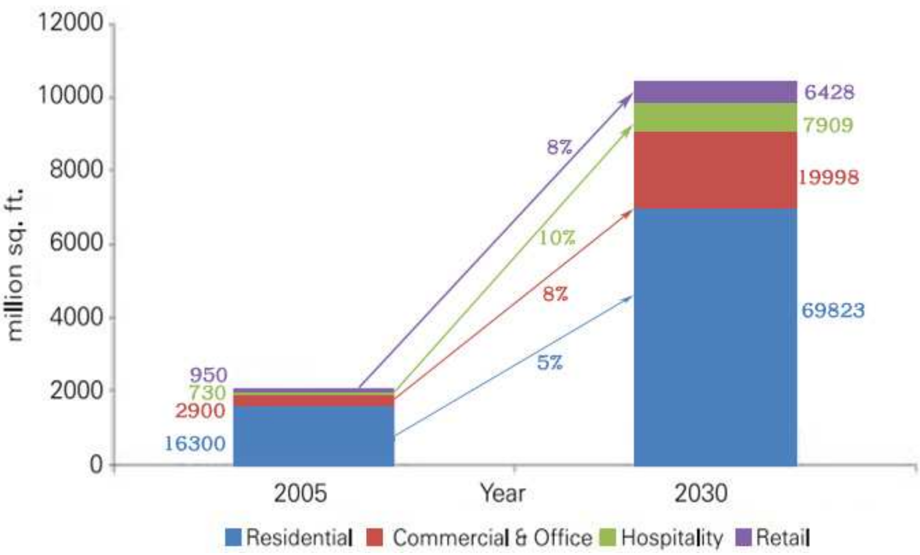


Figure 3: Future Trend of Building Sector in India

SCOPE AND LIMITATIONS

Study and observation of climatic factors of warm humid climate through out the year which plays a major role in fenestration design. Case study of traditional windows which give clues for the innovative ideas about window design. The scope includes literature study about the human comfort, ventilation, lighting, window typology and classification, external shading devices, measuring units, quantifying methods of variables ,etc. and testing the perfomance of various windows and external shading devices using a physical scaled miniature model of a living room in an individual type dwelling. This can be done with the use of a wind tunnel and a solarscope, using a virtual model. To conclude with the comparison of the results arrived by the itrations, along with the help of computer simulation softwares like Autodesk Ecotect and Design builder CFD (computational fluid dynamics) respectively for lighting and ventilation.

Air conditioned residential buildings are not considered for the above, design principles of windows are applicable to warm humid climate puducherry. Integration of mechanical ventilation system is not applicable and the climatic factors are limited to lighting and ventilation.

WARM HUMID CLIMATE

In the context, warm and humid climate is characterized by high relative humidity, around 70-90 % and high precipitation levels, about 1200 mm per year. The temperatures usually vary between 25–35 ºC in summer while in winter, temperatures vary between 20–30 ºC.

The building design in this climate should aim at reducing the heat gain by providing shade and promoting heat loss by maximizing the cross ventilation. Dissipation of humidity is also required to reduce discomfort of the habitants.

Climate data for Pondicherry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	29.7 (85.5)	30.8 (87.4)	32.3 (90.1)	34.2 (93.6)	37.1 (98.8)	36.9 (98.4)	36 (96.8)	35.5 (95.9)	34.4 (93.9)	32.2 (90)	30.2 (86.4)	29.5 (85.1)	33.233 (91.825)
Average low °C (°F)	20.5 (68.9)	21.3 (70.3)	23.3 (73.9)	25.9 (78.6)	26.8 (80.2)	26.5 (79.7)	26.1 (79)	25.5 (77.9)	25 (77)	24.2 (75.6)	22.8 (73)	21.2 (70.2)	24.092 (75.358)
Rainfall mm	15.5	30.8	25.7	28.8	64.9	55.7	57.8	118.4	128.2	252.3	356.6	292.7	118.95
Avg. rainy days	1.5	1	0.8	0.7	2.5	3.9	7.4	8.7	7.8	10.8	12.1	7.9	5.425

FENESTRATION

Windows may either be fixed or made to open. In a fixed window, the glass pane or the glazed shutter is permanently fixed. This type of window is used in situations where only light and view of the outside are needed, as no ventilation is possible through the window. In an operable type of window, the whole or part of a window can be opened. Windows with opening shutters may be classified as under according to the manner in which the shutters are arranged to open inside the frame as illustrated in figure 4.

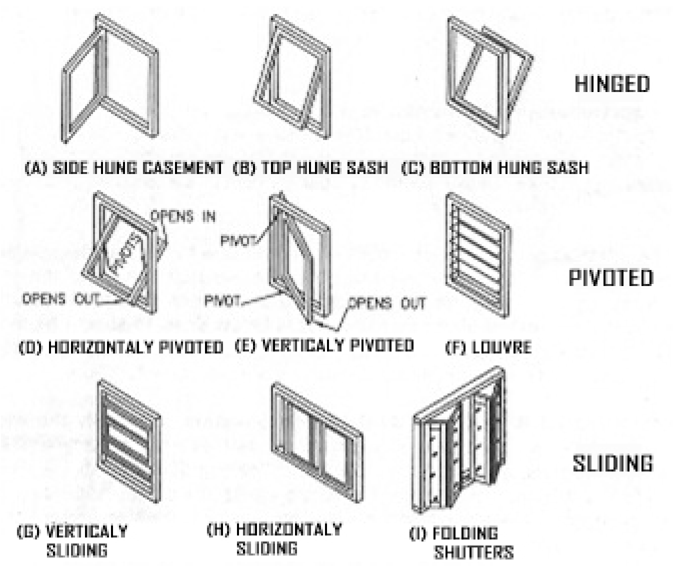


Figure 4: Types of Windows (Inspectapedia.Com)

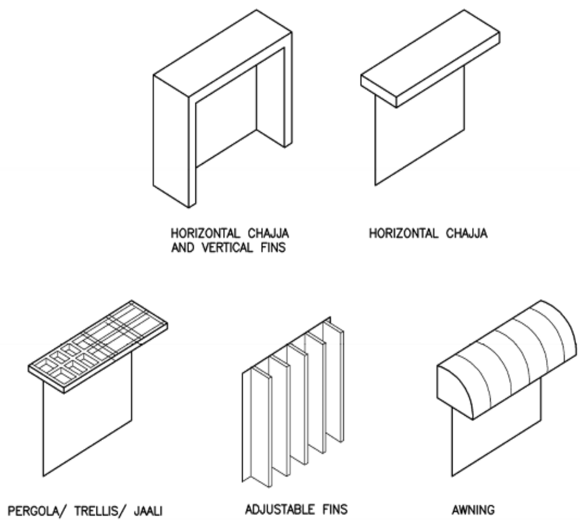


Figure 5: Types of External Shading

What ever may be the type of fenestration and the shading device, it should satisfy the functions like ventilation and air movement, day light admission, glare control, solar heat exclusion, closure of openings for exclusion of air at times, protection against burglar, pest and insect and hence satisfying the psycological comfort like view and visual effect or visual communication. It therefore includes the customization of the fenestration, which relies on the local climate. The classification is given in the tabel-2 below, based on the functions of fenestration and its components.

Fenestration	
Fenestration Components	**Fenestration Functions**
Size	Ventilation and air movement
Orientation and position	Closure for exclusion of air at times
Closing elements (sashes, shutters, glazing, etc.)	Daylight admission & glare control
Shading devices	Solar heat exclusion
Insect and fly screens	Insect, pest and burglar proofing
Security device (burglar bars)	View and visual effects

CASESTUDY

Puducherry was designed in grid pattern and it also features neat sectors and perpendicular streets as one of its planning qualities. The entire town is divided into two sections, one is the French Quarter and the other is the Indian quarter. In the French quarter, the buildings are typically in the colonial style with long compounds and stately walls. The Indian quarter consists of houses lined with verandas, large doors and grills. High ceilings and windows with louvers are also common, to promote air circulation and to limit the entry of direct sunlight.

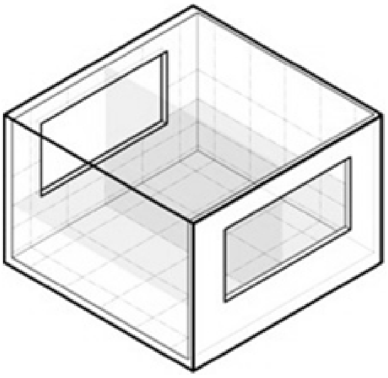
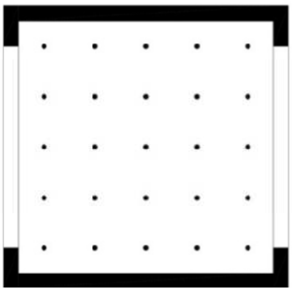
Most of the windows in the colonial style buildings does not have external shading device, where extensive use of louvers in window shutters acts as small horizontal shading device and some external sloped shading element has been added later as shown in figure 6 (a). Since windows open to the street and pedestrian path, wood woven mesh or louvered panels are used for privacy of interior space as shown in figure 6(a) & 6(b). Some windows are customised with multiple layers of shutters, the outer shutter with fixed louvers and opens outside where as the inner shutter is fully glazed which opens inside with burglar bars in between the two layers of shutters as shown in figure 6(d). If the outer shutter is closed and inner shutter is opened it provides ventilation, diffused day light and protects the driving rain. If the outer fixed louver shutter is opened and the inner glazed shutter is closed which provides only lighting, the indoor is kept air tight to enhance air conditioning systems, which means it has provisions for both active and passive cooling modes.




Figure 6(a) **Figure 6(b)** **Figure 6(c)** **Figure 6(d)**

METHODOLOGY

The model size is kept constant but the window sizes, types and location of the inlets and the outlets are varied, external shading devices are used to demonstrate and analyse the effects of natural ventilation and lighting. A miniature model of 10m X 10m X 04m, resembling the living room of a individual residence with rough open on two of the sides and transparent acrylic sheets on the other two sides for visualisation. A grid of 25 points with equal spacing has been marked as reference points to take measurements.


View **Plan** **Section**

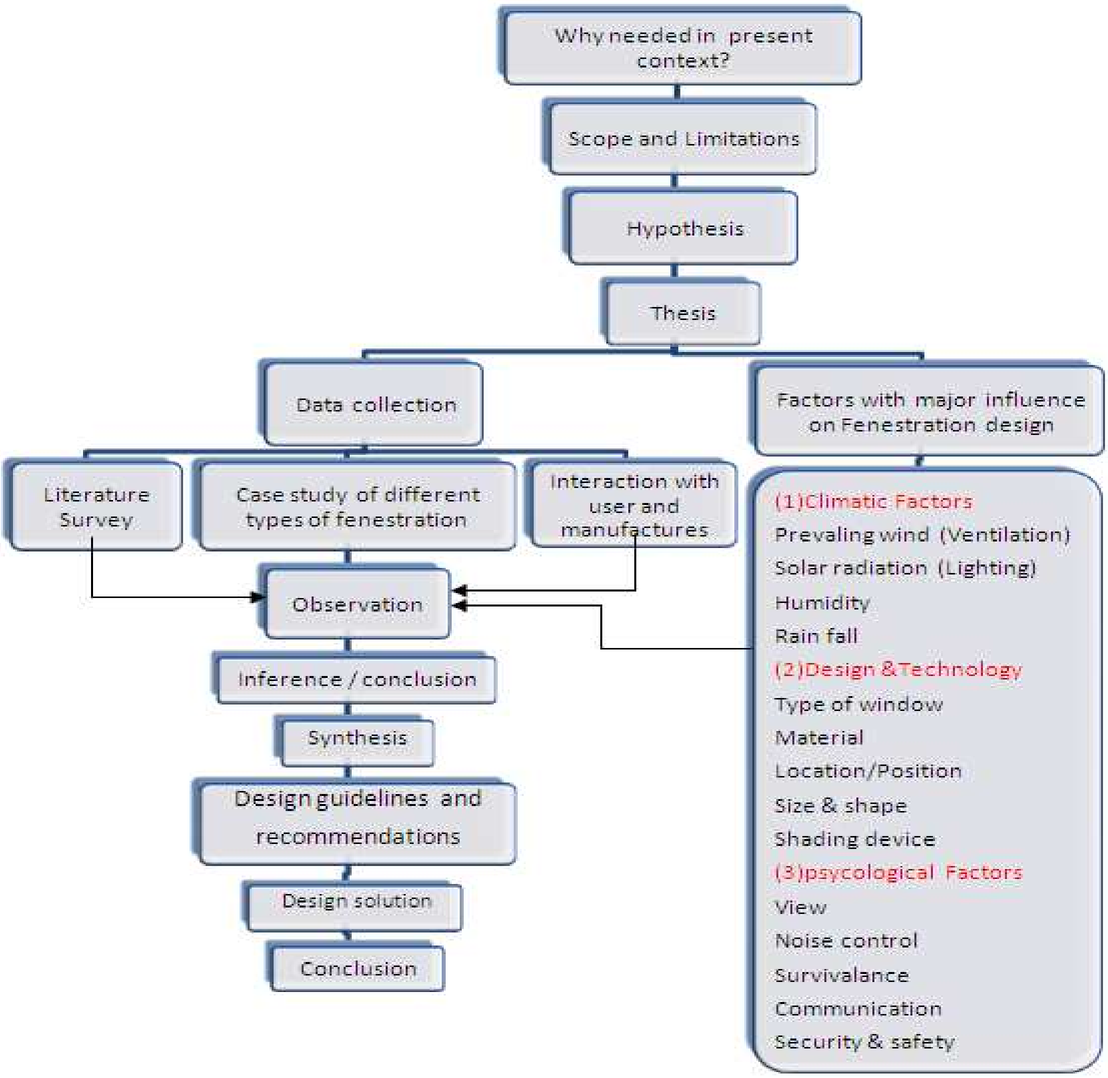
The scaled physical model is tested in a wind tunnel for air distribution and air temperature, with the help of hot wire anemo meter. The velocity and temperature is measured for each point, marked at a reference plane as shown in the above figure. The same is done for different types of windows, external shading device combinations and without the shading device, hence it helps us to study the influence of shading device in natural ventilation.

A virtual model is created and tested for ventilation simulation at various orientations, different types of windows and shading devices with the help of computational fluid dynamics (CFD) software Design Builder. The results of both wind tunnel and design builder CFD are compared for effectiveness.

The scaled physical model is tested under a soloarscope with different types of windows and sunshades, using computer simulation software. Autodesk Ecotect lighting analysis is made for the virtual model and tested for different window types and shading devices.

To reduce thermal mass, light weight construction is preferred in warm humid climate and shading devices should be used to avoid solar heat gain through windows, nowadays advanced energy efficient glazings are available in the market which minimizes unwanted solar gains while maximizing the amount of useful daylight in the buildings. Multiple glazing, solar control glazing, heat reflecting glasses, low-e glazing, etc are some of the glazing's available for solar heat exclusion in addition to shading devices. Burglar bars and fly protection screen should be considered in effective opening area of the window and the correction factor should be arrived for these, else it should be included in the window performance simulation.

FLOW DIAGRAM OF METHODOLOGY



CONCLUSSIONS

It is very difficult to satisfy all the functions like ventilation, air movement, day lighting, glare control, exclusion of solar heat and pest control in a single window. Fenestration can be of multiple windows in which each can satisfy one different function. But based on the experiments and window performance analysis a fitness value can be arrived for different types of windows and external shading device combinations. This fitness value is arrived based on the individual functions, performance mean values from the experiments and also design guide lines of fenestration for maximum control over climatic factors that are arrived.

REFERENCES

1. Dr. Kirit Parikh., (2011) " Interim Report of the Expert Group on Low Carbon Strategies for Inclusive Growth" Planning Commission Government of India, Yojana Bhawan, Sansad marg, New Delhi.
2. Aravind Krishna, Nick backer, Simos yannas, SV Szokolay., (2009) "Climate Responsive Architecture" a design hand book for energy efficient buildings,Tata McGraw Hill Education Private Limited, New Delhi.
3. O H Koeinsgsberger, T G Ingersoll, Alan Mayhew, SV Szokolay, (2010) "Manual of Tropical Housing And Building" Climatic Design, University Press (India) Private Limited, Hyderabad.
4. "Climate responsive building", SKAT, (1993).
5. Indian Standard, "Code of practice for natural ventilation of residential buildings" IS: 3362 – 1977.
6. Indian Standard, "Guide for day lighting of buildings" IS: 2440 – 1975.
7. Indian Standard, Recommendations for orientation of buildings IS: 7662 (part-1) – 1974.
8. Teri, "Energy – efficient buildings in India", Mili Majumdar,(2001) Ministry of Non-Conventional energy sources and Tata energy research institute, New Delhi.