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RESIDENTIAL ENVELOPE DESIGN IN TROPICAL WARM HUMID CLIMATE

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Abstract: Amongst the innumerable constraints that the architect faces during the design of buildings, climate probably presents one of the major forces. The climate of a region presents a set of conditions, which need to be addressed adequately in order to produce contextual buildings. Buildings constructed without regard to surrounding climate can, no doubt, operate given enough energy input to correct resulting problems, whether they concern over-heating, darkness or heat loss. However, such use of active energy is wasteful, and can harm the environment. Moreover access to such energy is beyond the reach of much of the population of developing countries.The extremes of Climate post challenge to the building elements, Building Skin or Building Envelope has to face the Brunt to the most. Thus, its design and treatment for better thermal performance is extremely significant in the present scenario of energy deficiency. By designing envelope according to the climate, making suitable material choices, fenestration and shading devices sizes, the load on the mechanical heating and cooling can be reduced.

***Index Terms* - Building Skin, Building Envelope, sustainable, passive solar energy, Warm humid, Design Strategies**

1 INTRODUCTION

Building envelopes have always been designed and constructed as shields to the extremities of prevailing climates. Nineteenth century experts discovered and explained the concepts of building physics of materials used in the building envelope. The 20th century developments introduced new materials and technologies which widened the scope of design options in building envelopes, but as a result, buildings came up with large areas of windows which led to uninterrupted ingress of solar heat causing discomfort in the interiors. Such enormous amounts of solar heat gains had to be countered with the use of artificial means of cooling, which in turn increased the energy consumption of buildings. This paper focuses on the design of the envelope to suite the buildings in Tropical Warm Humid Climate.

2 BACKGROUND STUDIES

The heat transfer through different parts of envelope in to the living space is explained in the figure 1.

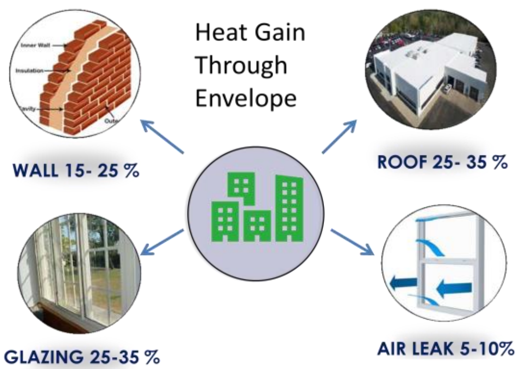

Figure 1- Heat Gain through Envelope

2.1 Things to consider while choosing Building Envelope

Key parameters to be considered while choosing building envelope is as follows

- Properties of Envelope Materials
- U-Factor or U-Value/R-Value
- Solar Heat Gain Co-efficient (SHGC)
- Window Wall Ratio(WWR)/ Skylight Roof Ratio (SRR)
- Solar Reflection Index (SRI)
- Visual Light Transmission (VLT)
- Building Envelope Sealing
- Energy Conservation Building Codes (ECBC)

2.2 Thermal Bridge

A thermal bridge is an area or component of an object which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer. Thermal bridging can be responsible for up to 30% of a dwelling's heat loss. Thermal bridges may be avoided with an appropriate structural composition and through insulation of the existing thermal bridges

2.3 ECBC Envelope –U value/ R Value for Opaque Elements

Total Thermal resistance RT of a plane element consisting homogenous layers perpendicular to the heat flow is calculated using formula:

RT: R si + Rt + R se

(Where Rt is the thermal resistance of components of Wall)

3 RESIDENTIAL COMMUNITY DESIGN AT THIRUVENCHERRY

3.1 Site Details

The site is located in Thiruvancherry, Chennai with an extent of about 15.75 Acres abutting Agaramthen road in the East. The site is almost a flat terrain with gentle slope towards the North and it is surrounded by vacant land on three sides

Figure 2- Site Location

3.2 Concept

The design focuses on utilizing the sites orientation to its maximum potential, and creating micro climatic zones in several pockets making the environment conducive to live in. The buildings are located in way to aid air flow in to the premium land parcels which are created within the site. The tall structures form a protective enclosure to the low rise zones in between. The buildings are oriented strategically so that, the air flowing in from predominant wind directions creates Ventury Effect at certain locations

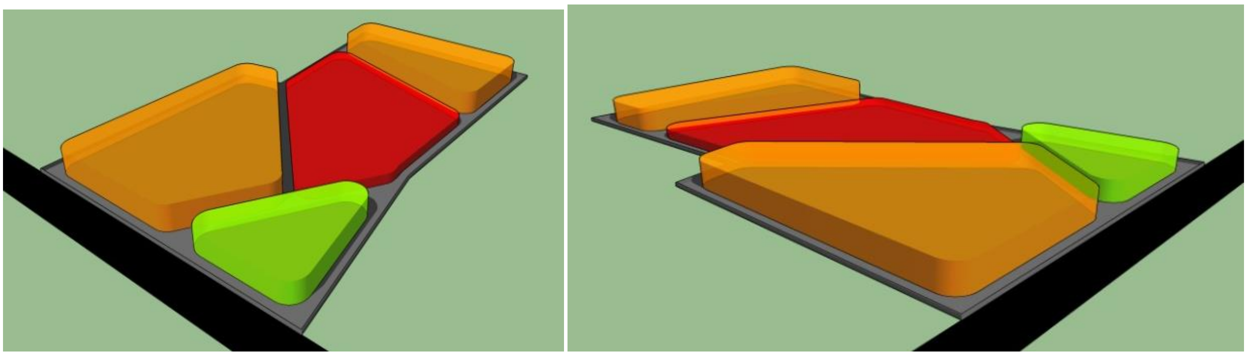

Figure 3- Massing Concept

3.3 Design

This project is Residential community design with Emphasis of Envelope design in Tropical warm Humid climate. The site is located in Thiruvancherry with extent of about 15.75 Acres.The community comprises 3BHK Blocks, 2BHK Blocks, Villas, Club house and Amenities.

Design focuses on making the Buildings climate responsive by creating micro-climatic conditions so that, it requires minimum Active energy to function

3.4 Aerial View- Master Plan

Figure 4- Aerial View-Master Plan

3.4 Sun path Study

The buildings are zoned in way to utilize the shadows of the structures enhancing the micro climate of the region. The actual sun path simulation was carried out for the month of May and September and it was observed to be effective. Interactive zones and play areas are shaded adequately for shadows of the taller structures nearby.

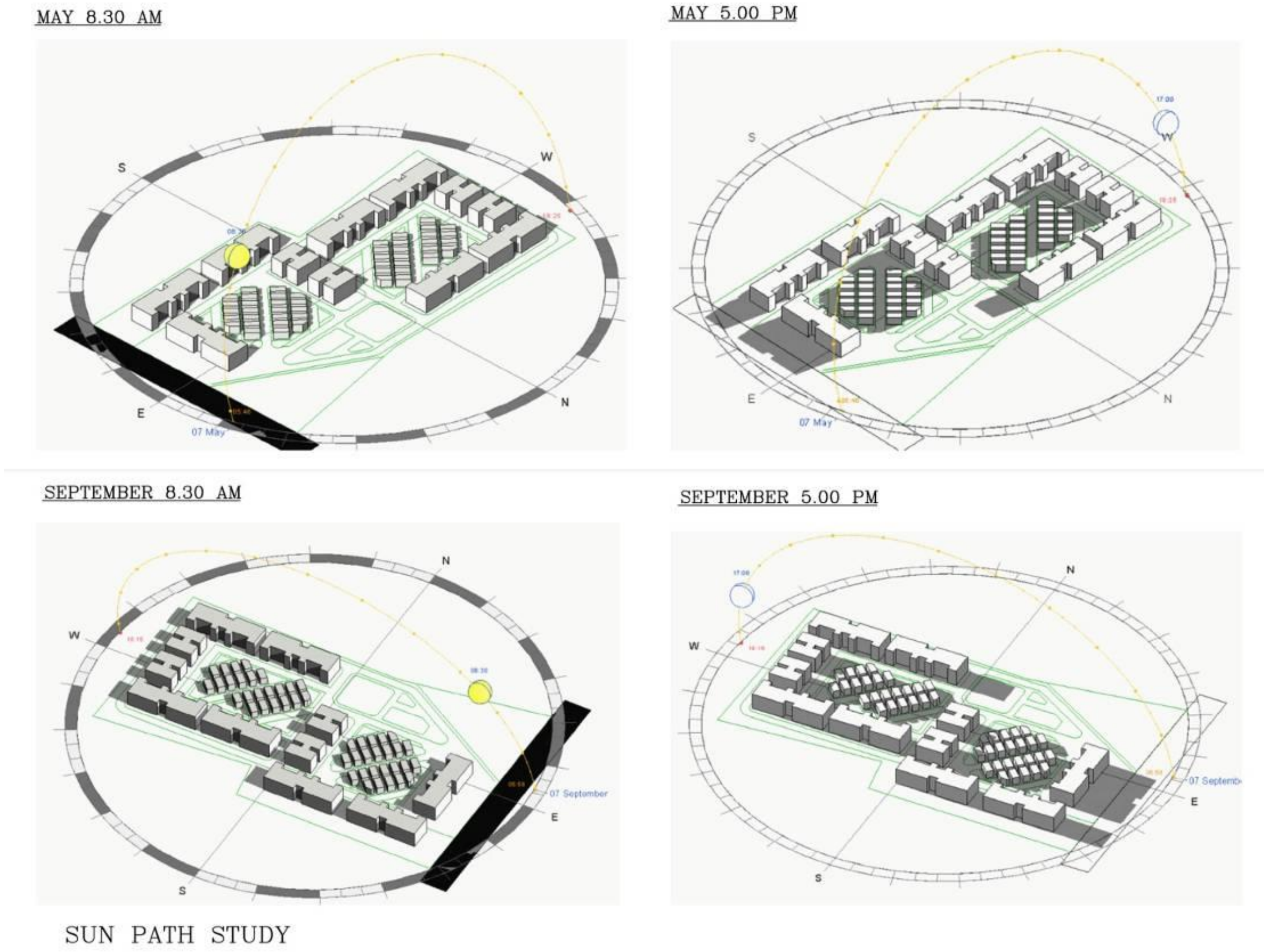

Figure 5- Sun path Study

3.4 Block plan

The individual units are delinked in order to avoid heat transfer. Openings are created strategically in order to aid the air flow and to carry the excess moister accumulated away from the habitable spaces.

Figure 6- 2 BHK Typical floor plan

3.5 Wing wall to aid airflow

In order utilize the prevailing winds throughout the season, wing walls are incorporated in the design, which directs the air flow effectively in to the habitable spaces.

Figure 7- 3 BHK Typical floor plan showing Wing wall

4 DESIGN CALCULATIONS

With all the effective design measures in terms of planning and selection of suitable construction material for warm humis climate, the following design parameters were achieved.

Table 1- 2 BHK- Window to Wall Ratio (WWR)

2BHK UNIT- WINDOW TO WALL RATIO				
S.No	**Room Name**	**Wall Area**	**Window Area**	**WWR in %**
1	LIVING ROOM	7.30	2.16	29.61
2	KITCHEN	7.52	1.26	16.77
3	BEDROOM 1	17.57	3.00	17.08
4	BEDROOM 2	4.80	1.44	30.00

Table 2- 3 BHK- Window to Wall Ratio (WWR)

3BHK UNIT- WINDOW TO WALL RATIO				
S.No	**Room Name**	**Wall Area**	**Window Area**	**WWR in %**
1	LIVING ROOM	15.00	5.25	35.00
2	KITCHEN	7.20	1.44	20.00
3	BEDROOM 1	23.10	3.24	14.03
4	BEDROOM 2	21.60	3.24	15.00
5	BEDROOM 3	9.75	1.62	16.62

Table 3- 3 shading coefficient of Windows

RESIDENTIAL DEVELOPMENT AT THIRUVANCHERRY				
	Windows Shading Coefficient			
S.No	Window	Description	Solar Heat Gain Coefficient	Shading Coefficient (External Element)
1	East	Low E Double Glazing Glass	0.65	0.76
2	West	Low E Double Glazing Glass	0.65	0.76
3	North	Single glass 4mm clear	0.80	0.93
4	South	Single glass 4mm clear	0.80	0.93

4.1 2-BHK Wall assembly U-Value calculations

R1 – Resistance for Layer 1(13mm plaster) 0.056 Km2/W (ECBC Table 11.4)

R2 – Resistance for Layer 2(200 mm AAC Block)= d2/ k2 = 0.2/0.8= 0.25 Km2/W

R3 – Resistance for Layer 3(50mm XPS)= d3/ k3 = 0.035 Km2/W

R4 – Resistance for Layer 4 (13mm plaster) 0.056 Km2/W (ECBC Table 11.4)

Minimum R- Value (Rt)= R1+R2+R3+R4

= 1+0.25+0.035+0.056 = 1.397

RT = Rse+ Rt + Rsi

= 1+1.397+0.05 = 2.437 W/M2K

Maximum U-Factor U =1/Rt = 1/ 2.437 **= 0.410 W/M2 K**

4.2 2-BHK RETV Calculation

RETV = 5.19(1-WWR)U opaque+1.34(WWR) U non-opaque+66.70 (WWR)SHGC

= 5.19(0.042)x(0.69)+1.34(23.36)x(0.85)+ 66.70(23.36)x 0.85/Area

=(0.150+26.60+1324.39) /120.45

= 1351.11/120.45

RETV = 11.21 (which is < 15 the permissible limit for India subcontinent condition)

4.3 3-BHK Wall assembly U-Value calculations

R1 – Resistance for Layer 1(13mm plaster) 0.056 Km2/W (ECBC Table 11.4)

R2 – Resistance for Layer 2(200 mm AAC Block)= d2/ k2 = 0.2/0.8= 0.25 Km2/W

R3 – Resistance for Layer 3(50mm XPS)= d3/ k3 = 0.035 Km2/W

R4 – Resistance for Layer 4 (13mm plaster) 0.056 Km2/W (ECBC Table 11.4)

Minimum R- Value (Rt)= R1+R2+R3+R4

= 1+0.25+0.035+0.056 = 1.397

RT = Rse+ Rt+Rsi

= 1+1.397+0.05 = 2.437 W/M2K

Maximum U-Factor U =1/Rt = 1/ 2.437 **= 0.410 W/M2 K**

4.4 3-BHK RETV Calculation

RETV = 5.19(1-WWR)U opaque+1.34(WWR) U non-opaque+66.70 (WWR)SHGC

= 5.19(0.049) x(0.69)+1.34(23.36)x(0.85)+ 66.70(23.36)x 0.85/Area

= (0.175+26.60+1324.39) /133.35

= 1351.16/133.35

RETV = 10.13 W/M2K (which is < 15 the permissible limit for India subcontinent condition)

5 CONCLUSIONS

In order to adopt passive design strategies effectively in warm and humid climatic conditions, it is important to consider the overall thermal performance of every building envelope components such as wall material, the optimal window to wall area, appropriate material for glazed windows and the right shading devices to accomplish thermal comfort.

In the proposed design, the achieved design parameters such as U-Values in the range of 0.4105 w/m2k and RETV values in the range of 11.23 in 2BHK and 10.13 in 3BHK are well within the permissible limit of 15 W/ m2 which ensured comfortable indoor living standard with minimum dependency on Active Energy. The proper selection of Low E coated glass for east and western windows shall eliminate unwanted heat transfer, the Thermal bridges are taken care by the use of 50mm XPS which shall directly cut down the heat transfer through opaque surface of the building envelope.

All the design strategies adopted and selection of materials for the Envelope to suite the Tropical warm Humid climate shall result in minimum 9-10% of cost saving on the Annual Electricity load. Buildings naturally functions like a living object taking care of itself with minimal energy.

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