Thermal Performance of Modern Low-Cost Housing Units in Deep South India and Provisions for Improving Thermal Comfort

Vincent Jayaseelan V [1], Ganapathy C [2]

[1] Research Scolar, Sathyabama University, Chennai, India
[2] Professor, St.Xaviers Catholic College of Engineering, Kanyakumari, India
e-mail: vvincentjayaseelan@gmail.com

Abstract

Low-cost housing is a major issue in a developing country like India. In a region located close to the equator, such as Deep South India, warm discomfort that occurs during the day time could become a problem unless houses are planned with careful consideration. The main drawback in the existing modern low-cost housing is that it is not congenial to live and work in tropical climate. Because of thermal discomfort, the occupants spend most of the time living and sleeping outdoors. For preliminary investigation on thermal performance, housing units at three different locations in the deep south were selected. The parameters that affect thermal comfort were measured for different configurations at an interval of three hours round the clock in a day in alternate months from January to December of 2006. Accounting the observations, the value of Tropical Summer Index (Sharma and Ali-1986) was determined and compared with that of the comfort temperature provision (Nicol.F.etal 1994). The result lie well beyond the level of comfort and the present research confirms the prevalence of thermal discomfort in all these housing units. The study highlighted that these units failed to provide thermal comfort mainly through lack of ventilation. This paper also presents a set of rules so that designers can easily include such rules at the stage of house-planning to bring down the parameters to comfort level.

Key words: Tropical Summer Index, Low-cost Housing, Dry Bulb Temperature, Relative Humidity

I. INTRODUCTION

It has been shown through many studies that traditional architecture has generally blended well with the prevailing climatic conditions to ensure thermally comfortable houses. However this practice has become much less common in recent times with the adoption of some modern architectural concepts in India with regard the climatic conditions prevailing in the area. Therefore, there is an urgent need to develop rules and concepts that show greater regard for climatic conditions. In this paper, attention was focused on tropical plains and tsunami hit coastal districts of Deep South India for developing such a set of guidelines.

II. OBJECTIVES AND METHODOLOGY

The main objective of the study is to grade thermal comfort of low-cost housing units and to compare the same with that of the existing thermal comfort provisions studying the relationship between the thermal distributions and the parameters such as air velocity, temperature and humidity. Also this paper suggests various measures to be taken to bring down the values of the parameters to comfort level.

For the present study, sample units of low-cost housing at Chenbagaramanputhur of Kanyakumari District, Ponnagudi of Tirunelveli District and Thiruvathavoor of Madurai District were selected. Indoor and outdoor measurements with Thermo- Anemometer, Thermometers with dry bulb and wet bulb and Thermo-Hygro clock were carried out for different windows at an interval of three hours round the clock in a day in alternate months from January to December of 2006.

These observations have been summarized and analyzed, Table 1. With reference to the psychrometric chart developed by Sharma & Ali (1986), value of Tropical Summer Index (TSI), the temperature represented by the dry bulb temperature, relative humidity or wet bulb temperature and wind speed was determined. The critical values of TSI were compared with that of the comfort temperature (T_c) calculated according to Nicol, F. et.al (1994), T_c=17.0 + 0.38 T_o where T_o, the outdoor temperature.

Fig. 1 Low-cost Housing Unit in Chenbagaramanputhur, Kanyakumari District

TABLE 1. A SET OF SAMPLE MEASUREMENT OBSERVED IN CHENBAGARAMANPUTHOOR, KANYAKUMARI DISTRICT

Time	Configuration	Factors	Nodal points inside the unit			Nodal points outside the unit			
			1	2	3	4	5	6	7
28-1-2006 3 pm	DOWO	Tdb (?C)	29.4	30.5	28.3	28.3	28.3	27.2	27.2
		Twb (?C)	27.8	27.8	27.2	26.7	26.7	26.1	76.1
		RH (%)	77	77	77	75	75	75	75
		WS (m/s)	0.5	0.4	0.5	0.5	0.5	1.0	1.0
	DCWO	Tdb (?C)	30.3	30.5	30.1	28.3	28.3	27.2	27.2
		Twb (?C)	28.3	28.3	27.8	26.7	26.7	26.1	76.1
		RH (%)	79	79	80	75	75	75	75
		WS (m/s)	0.4	0.3	0.6	0.5	0.5	1.0	1.0
	DCWC	Tdb (?C)	31.6	31.1	30.5	28.3	28.3	27.2	27.2
		Twb (?C)	29.9	29.9	28.4	26.7	26.7	26.1	76.1
		RH (%)	80	80	81	75	75	75	75
		WS (m/s)	0.1	0.1	0.0	0.5	0.5	1.0	1.0

Day : 28-1-2006 / 29-1-2006Tdb : Dry bulb temperatureRH : Relative Humidity
Direction of wind: From West- South WestTwb : Wet bulb temperature V (m/s): Wind Velocity

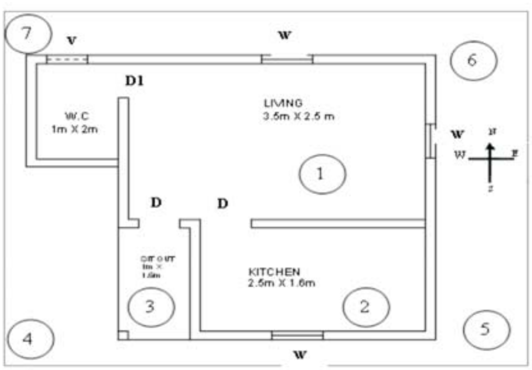


Fig.2. Plan Layout of the Housing Unit In Chenbagaramanputhur, Kanyakumari District

The floor plan of the sample units of Kanyakumari, Tirunelveli and Madurai Districts are respectively shown in figure 02, 04 and 06 which indicates the location of the windows available to open for ventilation and the location of the nodal points at which air temperature and velocity measurements were made. During the experimental work in the unit, the opening configurations used are detailed as follows:

1. Main Door and Windows Opened (DOWO).
2. Main Door Closed and Windows Opened (DCWO).
3. Main Door and Windows Closed(DCWC).

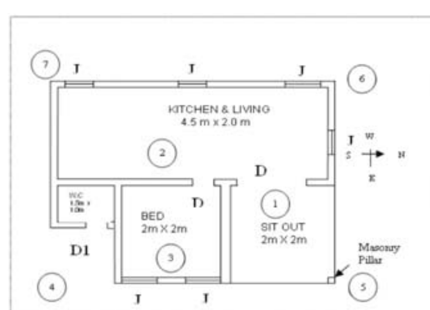
Specifications:

W- Window 0.6m x 0.75m V 0.6m x 0.45m

D Door 0.9m x 1.9m D1 Door 0.6m x 1.8m

O Nodal points where observations had been made

Fig.3. Low-Cost Housing Unit in Ponnagudi, Tirunelveli District



Specifications:

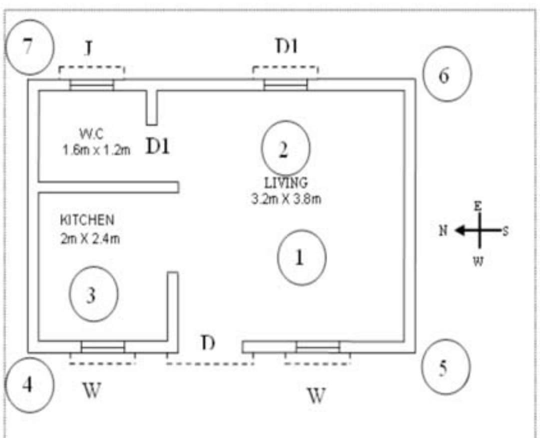
J Jolly work 0.75m x 1.0m V 0.6m x 0.45m

D Door 0.9m x 1.9m D1 Door 0.6m x 1.8m

O Nodal points where observations had been made

Fig .4. Plan layout of a housing unit in Ponnagudi, Tirunelveli district

Fig. .5. Low-cost housing unit in Thiruvathavoor, Madurai district



Specifications

D Door (Steel) 0.9m x 2.0m

W Window (Steel) 0.9m x 0.9m

J Jolly work 0.95m x 0.6m

Wall Thickness 0.2m

D1 Steel Door 0.8m x 0.8m

Fig. 6. Plan layout of a housing unit in Thiruvathavoor, Madurai district

III. EVALUATION OF THERMAL COMFORT

The sample set of measurements taken in the first three nodal points for the configuration specified, the corresponding value of TSI and the calculated comfort temperature Tc(oc) are respectively presented below for the three sample locations.

TABLE 2. Maximum values of indoor TSI and outdoor TSI comfort temperature for the housing unit in Chenbagaramanputhoor, Kanyakumari District.

TSI (maximum)		Jan2006	Mar 2006	May 2006	July2006	Sep 2006	Nov 2006
TSIi (indoor)	Tdb(oc)	30.3	33.6	35.1	29.6	32.4	31.2
	Twb(oc)	28.3	30.0	32.2	27.8	29.1	28.3
	V(m/s)	0.4	0.5	0.3	1.0	0.3	0.4
	TSIi(oc)	30.8	33.1	35.8	29.5	32.5	31.4
TSIo (outdoor)	Tdb(oc)	28.5	29.2	31.2	27.2	31.1	30.7
	Twb(oc)	26.7	27.2	28.3	25.4	28.9	28.7
	V(m/s)	1.0	1.5	0.6	1.2	1.4	2.0
	TSIi(oc)	27.9	28.5	31.1	26.1	30.6	29.6
Comfort temperature Tc(oc) =17.0+0.38 TSIo		27.6	27.8	28.8	26.9	28.6	28.2

Configuration: Doors closed-Windows opened

TABLE 3. Maximum values of indoor TSI and outdoor TSI comfort temperature for the housing unit in Ponnagudi, Thirunelveli District

TSI (maximum)		Jan2006	Mar 2006	May 2006	July2006	Sep 2006	Nov 2006
TSIi (indoor)	Tdb(oc)	31.8	34.9	38.1	35.1	36.6	32.1
	Twb(oc)	27.8	29.8	30.6	31.8	32.6	28.1
	V(m/s)	0.1	0.0	0.0	0.2	0.1	0.3
	TSIi(oc)	32.2	35.8	38.7	36.4	37.7	32.0
TSIo (outdoor)	Tdb(oc)	31.2	34.5	37.6	33.6	35.6	31.0
	Twb(oc)	26.7	28.9	29.4	29.1	31.4	26.5
	V(m/s)	2.	1.2	0.3	2.6	1.8	2.0
	TSIi(oc)	29.1	33	36.6	31.2	34.4	29.5
Comfort temperature Tc(oc) =17.0+0.38 TSIo		28.1	29.5	30.9	28.9	30.0	28.2

Configuration: Doors closed-Windows opened

TABLE 4. Maximum values of indoor TSI and outdoor TSI comfort temperature for the housing unit in Thiruvathavoor, Madhurai District

TSI (maximum)		Jan 2006	Mar 2006	May 2006	July 2006	Sep 2006	Nov 2006
TSIi (indoor)	Tdb(oc)	30.8	35.5	40.0	38.5	36.6	30.4
	Twb(oc)	25.6	28.3	31.7	32.1	30.0	26.5
	V(m/s)	0.1	0.0	0.1	0.3	0.1	0.5
	TSIi(oc)	30.9	36	39.6	38.8	37.2	30.1
TSIo (outdoor)	Tdb(oc)	31.1	35.1	39.7	37.8	35.8	29.6
	Twb(oc)	25.0	27.8	30.6	31.0	30.4	28.4
	V(m/s)	0.8	0.5	1.1	2.5	1.4	2.3
	TSIi(oc)	29.7	34.3	37.4	35.2	35.4	29.0
Comfort temperature Tc(oc) =17.0+0.38 TSIo		28.3	30.0	31.2	30.4	30.5	28.0

Configuration: Doors closed-Windows opened

A graphical comparison of TSI with that of the comfort temperature Tc for the sample units are shown in figures 07, 08 and 09.

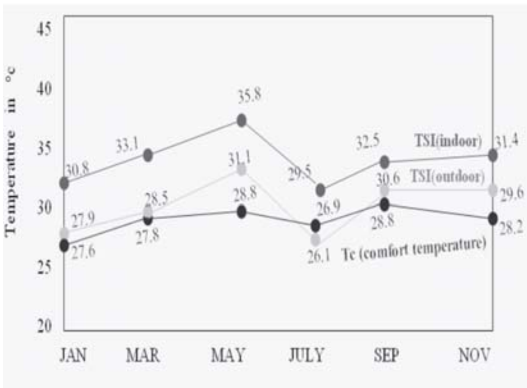


Fig. 7. Comparison of TSI with Comfort Temperature (Tc) for the Sample Unit In Kanyakumari District

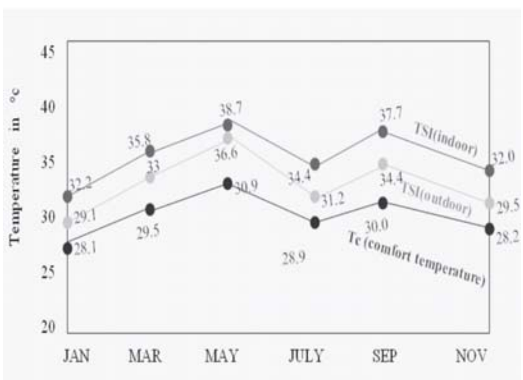


Fig.8. Comparison of TSI with Comfort Temperature (Tc) for the Sample Unit In Tirunelveli District

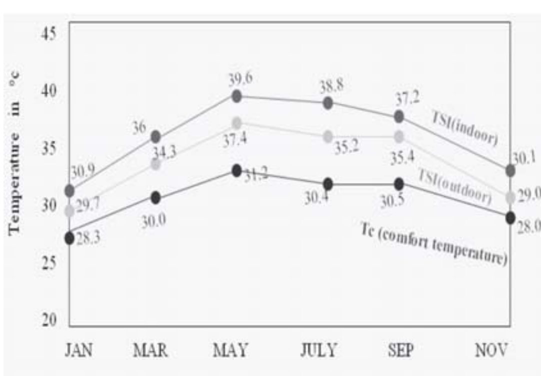


Fig. 9. Comparison of TSI with Comfort Temperature (Tc) for the Sample Unit In Madurai District

The results depicted in the charts shows that the TSI (indoor) is well deviated from the line of comfort for the sample housing units of all selected locations. The results agree with those of Rajeh (1994) who reported that terrace housing is often poorly discomfort occurs.

IV. CONCLUSION

The work showed that the occupants of these units feel discomfort and they spend most of their time living and sleeping outdoors. Even when all the windows and doors are open, the wind velocity is only marginally increased. During night, when the doors and windows are shut, the temperature and humidity increase inside the room, compared to the outside. Since the magnitudes of parameters are well beyond the level of comfort, achieving any degree of thermal comfort is difficult as such. The study highlighted that these units failed to provide thermal comfort mainly through lack of ventilation.

V. SUGGESTIONS FOR IMPROVING THERMAL PERFORMANCE IN HOUSING UNITS

Good ventilation and heat insulating construction materials provide comfort. It is essential to maintain the temperature limits inside the building and to remove the air, vitiated by respiration, bacteria and unpleasant odours. Poor ventilation gives rise to a feeling of discomfort to the inhabitants, because it causes increase in temperature and humidity, which leads to sweating. The want of fresh air produces headache, sleepiness, laziness and un-attentiveness.

From the viewpoint of comfortable living and working conditions, the thermal performance could be improved by adopting the following recommendations.

1. The orientation of the house could be such that the front of the unit faces either south or north. This will allow protection for most of the openings from direct solar radiations.
2. Vegetation and trees in particular, very effectively shade and reduce heat gain. It also causes pressure differences, thereby, increasing air speed and directing air flow.
3. The ground surfaces should preferably be green in order to minimize heat gain.
4. The ratio of perimeter to area (P/A) of the unit should be kept to a minimum to minimize heat gain and to maximize air movement.
5. Surface area to volume ratio of the building (S/V) should be as low as possible as this would minimize heat gain

6. In hot-dry climates windows and doors need to be appropriately shaded.

7. Light coloured surfaces will result in greater reflectivity & re-radiation and therefore, it is preferable.

8. A rough textured surface (a grit finish) causes self-shading and therefore, it is preferable to minimize heat.

9. It is advisable to provide a false ceiling for the house so that infiltration through the roof could be reduced.

10. Wall materials and roof materials should be of low transmittance and low heat capacities.

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