INDOOR THERMAL PERFORMANCE OF VENTILATED DWELLINGS USING FLY SCREENS IN THE HOT-HUMID CLIMATE OF CHENNAI, INDIA

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ABSTRACT

In a hot-humid tropical climate, indoor thermal performance can be enhanced by comfort ventilation. Indoor ventilation depends upon building opening size. But risks involved in providing openings include ingress of mosquitoes and insects which thrive in the tropical climate. A practical and prevalent option to prevent insects in ventilated dwellings of the tropical, hot-humid city of Chennai, India is through the use of fly screens. Fly screens, when used over openings, prevent a certain quantum of solar radiation and wind from entering inside the rooms. Reduced direct solar radiation prevents the indoors from heating up, while reduced wind movement prevents the cross ventilation. Therefore, it is important to know the indoor thermal performance of ventilated rooms in the presence of fly screens with changing opening sizes. The criterion to evaluate indoor thermal performance in this paper is indoor air temperature. The aim of this research is to investigate the influence of fly screens on openings with varying sizes, in a naturally ventilated dwelling in the hot-humid climate of Chennai, India, during the summer period. The results of the study show that fly screens raise the indoor air temperature when openings are in the range of 100% to 35% of the room floor area. There is no significant change in the indoor air temperature when the opening sizes are less than 30% of the room floor area.

KEY WORDS

thermal performances, hot-humid climate, natural ventilation, fly screens, opening size

1. INTRODUCTION

A hot-humid tropical climate is largely found in the equatorial belt comprising of highly populous and economically developing countries. Almost seventy nations, including India, with roughly 70% of the world population are located here. (Kaushik 1988). Use of active means such as air conditioners is not common in general households in this part of the world. Only simple passive techniques are employed to protect the building indoors from the adverse effects of climate due to economic constraints. Studies by Koenigsberger (1973), Givoni (1994) and Amin (1983) suggest that the only passive means of achieving comfort in hot-humid conditions is through comfort ventilation, usually achieved by cross-ventilation of rooms. But it is not practical to suggest openings without considering the ingress of mosquitoes and pests.

The aim of this paper is to investigate the impact of fly screens on varying building openings in a naturally ventilated dwelling in a tropical hot-humid climate of Chennai, India, during the hottest part of the year.

2. CONTEXT OF THE STUDY—LOCATION AND CLIMATE

The study is conducted in the hot-humid climate of Chennai, India. India lies on the equatorial belt experiencing 'tropical climate' (figure 1). The Bureau of Indian Standards, Climate Classification IS: 3792 (1978), classifies the climate of India into four major types of climate relevant to building design, namely,

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FIGURE 1. Climate classification of Earth. Source: www.wikimedia.org/wiki/World_population as on 12.12.2007.

hot and arid, hot and humid, warm and humid, and cold zones (BIS-SP: 41 1987). Of particular significance is the coastal belt of India, as numerous cities and towns are located on the coast. 35% of the Indian sub-continent which is surrounded by the Arabian Sea, the Indian Ocean, and Bay of Bengal comes under the coastal area. The total population of 417.61 million people living in these coastal areas account for 42% of India's population. It is largely this zone, which is classified as a hot and humid climate in India.

The Bureau of Indian Standards describes hot-humid climate as the region, where mean daily maximum dry bulb temperature is above 32°C and relative humidity of more than 40% prevail during the hottest month of the year, and where the altitude is not more than 500mtrs. above Mean Sea Level (MSL). There is very little seasonal variation throughout the year. The other features of this climate type are as follows: Humidity remains high for most parts of the year. It remains at 75% most of the time, but may vary from about 55% to 100%. Sky conditions are cloudy throughout the year. Wind velocities are low. Calm periods are frequent. There are one or two dominant wind directions. Precipitation occurs due to the monsoon or due to the depression over the coastal sea. Thunderstorms are accompanied by air-to-air electric discharge. A special characteristic of this climate type is the seasonal abundance of mosquitoes and other insects (Koenigsberger 1973).

3. SIGNIFICANCE OF FLY SCREENS IN HOT-HUMID CLIMATE

The tropical hot-humid countries such as India have to deal with insects such as mosquitoes and flies. Having known that mosquitoes and pests transmit a variety of diseases (Tyagi 2004), preventive measures include use of mosquito repellants and lotions. On prolonged exposure, these can cause respiratory side effects and involve recurring costs. Therefore, the best way of protection is to prevent the entry of pests inside the house (Snehelatha 2003). 'Malaria Research Centre', an apex body in India working on the prevention and control of mosquito and malaria, recommends house screening with mosquito nets of

1.5 mm size holes as a physical and environmental friendly method for prevention of this menace (Vasudevan 2000). Since the house needs to be ventilated in order to enhance indoor thermal conditions, use of fly screens is the best way to prevent the entry of these insects and at the same time benefit from natural ventilation.

These insect screens can prevent the entry of direct solar radiation inside the building. At the same time, the use of insect netting is found to greatly reduce the scope of air flow indoors (Mallick 1996; Konya 1980 and Fry and Drew 1956). Tantasavasdi has found that although the screens reduce the velocity of the wind, the wind speed is still high enough to shift the indoor condition into the comfort zone (Tantasavasdi et al. 2001).

The only passive means of comfort in hot-humid climates is by comfort ventilation through provision of openings facilitating cross-ventilation. But the same opening, when not adequately protected, facilitates the entry of mosquitoes and flies. Therefore, it is important to know the impact on indoor temperature due to the fly screens on these opening sizes. But very few studies on the impact of fly screens on indoor thermal performances of naturally ventilated buildings have been carried out.

4. CRITERIA FOR EVALUATING INDOOR THERMAL PERFORMANCE USING FLY SCREENS

In order to quantify indoor thermal quality, physical parameters such as temperature, humidity and air velocity need to be measured (Awbi 1995). Quantification involves measurement of parameters under consideration. Certain parameters such as temperature are easy to measure and quantify as against certain parameters such as wind speed. This is because wind speed and direction inside a room change constantly (Vijayalaxmi 2008). When large quantum of data are involved, it is practically difficult to adapt a complex parameter for evaluation of thermal performance. Therefore, for the purpose of this research, indoor air temperature is assumed to be the criteria for evaluating thermal performance of buildings. An attempt by Ahmed (1994) to evaluate designed spaces and create guidelines for use by architects was on the basis of indoor air temperature. Studies by Humphreys and Nicol (1994) assume that the indoor air temperature is a sufficient index of warmth of the environment. Therefore, the main criterion for assessing thermal performance in this research is indoor air temperature.

5. METHODOLOGY

This study adopts an experimental method using the direct index method, whereby parameters that can be measured as a function of thermal performance are collected for analysis. The direct method is followed, since a large quantum of data had to be collected. Given a particular location, climate type and building typology, it is feasible to formulate statistically-driven empirical models that would be valid for the majority of buildings under the same conditions. Studies from primary surveys have shown that similar building materials and design features are employed in Chennai city (Vijayalaxmi 2008). The findings are in line with the information on the Census of India (Census 2001). Based on building material and design data collected from a survey of 96 dwelling units of housing settlements in Chennai city, a full scale dwelling unit is constructed to carry out the experiment. The dwelling, comprising of four rooms, is designed to modify its opening sizes (figure 2).

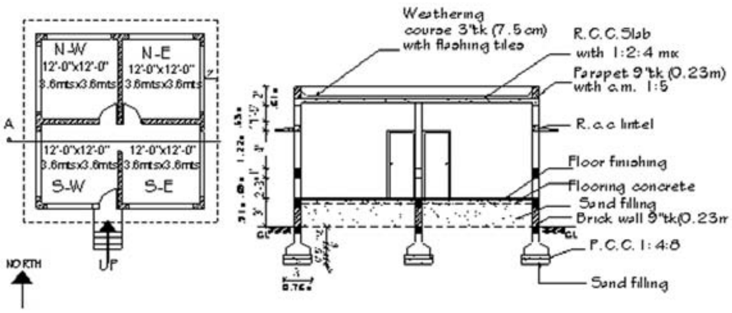


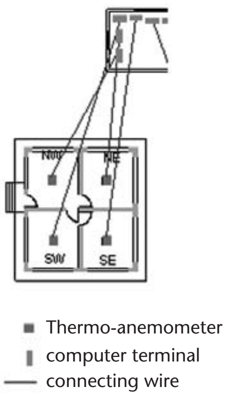
FIGURE 2. Plan and Section of the experimental model.

FIGURE 3. Photograph of the experimental model with the fly screen over the opening.

The photograph of the experimental full-scale model house along with the fly screens is shown in figure 3.

Indoor air temperature changes at every half hour interval are collected simultaneously from these four rooms for fourteen opening conditions during the summer period. The opening sizes vary from 100% of the floor area to 5% of the floor area. Indoor air temperature changes are collected in the presence and absence of fly screens for every opening condition. The fly screens used in this research are made of plastic with 1.50 mm mesh grade, which is normally used in residences in the study area. During conduct of experiments, the fly screens are placed along the inside of the openings. A digital thermo-anemometer is placed in the centre of each room and connected to a computer for capture of data (figure 4).

FIGURE 4. Data capture of indoor air temperature from the experimental model.



The four computers connected to the instruments in each of the four rooms are placed in a data monitoring room. Thus indoor air temperature changes are automatically recorded on the computer. The schedule of data collection is shown in Table 1.

6. IMPACT OF USE OF FLYSCREENS

When the opening percentages are large, of the order of 100% to 50%, the indoor temperature is elevated by 3°C. This is because of lack of wind movement due to the fly screens. Therefore, heat gets trapped inside, increasing the indoor temperature. As a case to this point, the comparison of indoor air temperature in the presence and absence of fly screens for the four rooms along the cardinal directions for an opening size of 70% is shown in figure 5.

When the opening percentage is between 50% to 35%, the indoor temperature is higher by as much as 2°C (figure 6).

It is found that when the openings are of the order of 30% to 5%, there is not much impact of the fly screens on the indoor air temperature (figure 7 and figure 8 respectively). This is because the impact of solar radiation responsible for increasing indoor temperature and the wind from outside which carries the hot wind out of the rooms neutralize each other.

There is no significant difference in indoor temperature in the presence of fly screens when openings are less than 30% of the floor area. The impact of fly screens with varying opening sizes is shown in Table 2.

7. DISCUSSION

The results of the study indicate that it would be prudent to have openings of 30% or less when

TABLE 1. Schedule of data collection.

Sl. No.	Date of data collection	Percentage of floor area of openings and condition of openings	Window to Wall ratio of openings
1	23-Mar-06	100% opening	0.51
2	26-Mar-06	100% with opening with fly screen	
3	27-Mar-06	85% opening	0.48
4	28-Mar-06	85% with opening with fly screen	
5	3-Apr-06	70% opening	0.42
6	10-Apr-06	70% opening with fly screen	
7	17-Apr-06	60% opening with fly screen	
8	19-Apr-06	60% opening	0.36
9	21-Apr-06	50% opening	0.30
10	26-Apr-06	50% opening with fly screen	
11	29-Apr-06	45% opening with fly screen	
12	3-May-06	45% opening	0.27
13	6-May-06	40% opening	0.24
14	8-May-06	40% opening with fly screen	
15	2-Jun-06	35% opening with fly screen	
16	3-Jun-06	35% opening	0.21
17	5-Jun-06	30% opening	0.18
18	8-Jun-06	30% opening with fly screen	
19	11-Jun-06	25% opening with fly screen	
20	19-Jun-06	25% opening	0.15
21	21-Jun-06	20% opening with fly screen	
22	24-Jun-06	20% opening	0.12
23	7-Jul-06	15% opening with fly screen	
24	8-Jul-06	15% opening	0.09
25	10-Jul-06	10% opening	0.06
26	14-Jul-06	10% opening with fly screen	
27	15-Jul-06	5% opening with fly screen	
28	18-Jul-06	5% opening	0.03

fly screens are to be used. This study is limited in understanding the impact of fly screens on indoor thermal performance of ventilated rooms. Impact of many other peripherals, such as ceiling fans, human occupancy, clothing level, activity level, etc. on indoor thermal performance need to be studied through simulation or experimental method to have a comprehensive understanding of indoor thermal conditions in dwellings of a hot-humid climate.

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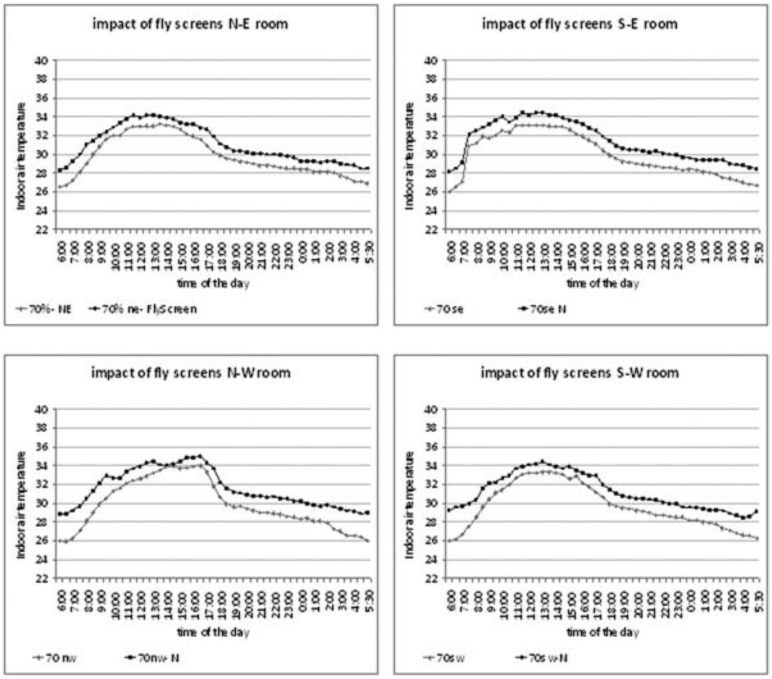

FIGURE 5. Impact of fly screens on the indoor temperature for an opening size of 70%.

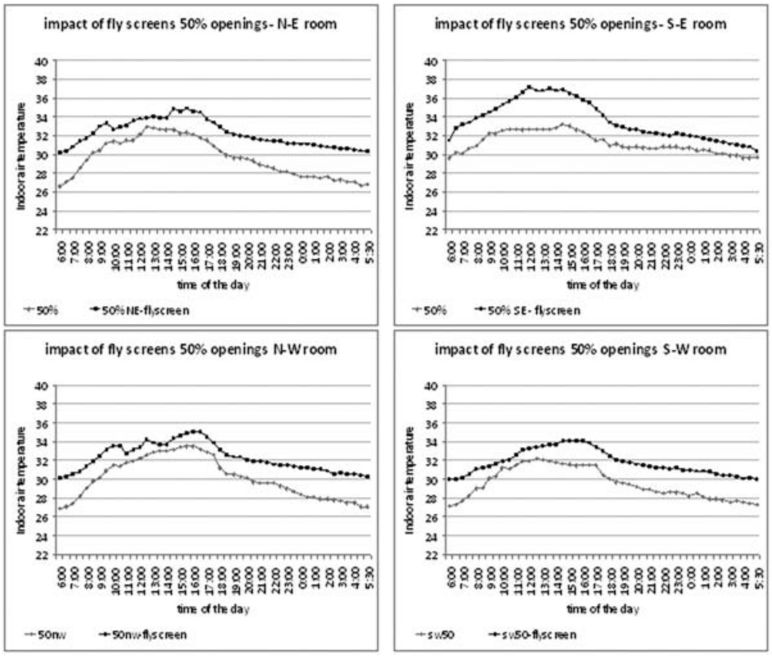

FIGURE 6. Impact of fly screens on the indoor temperature for an opening size of 50%.

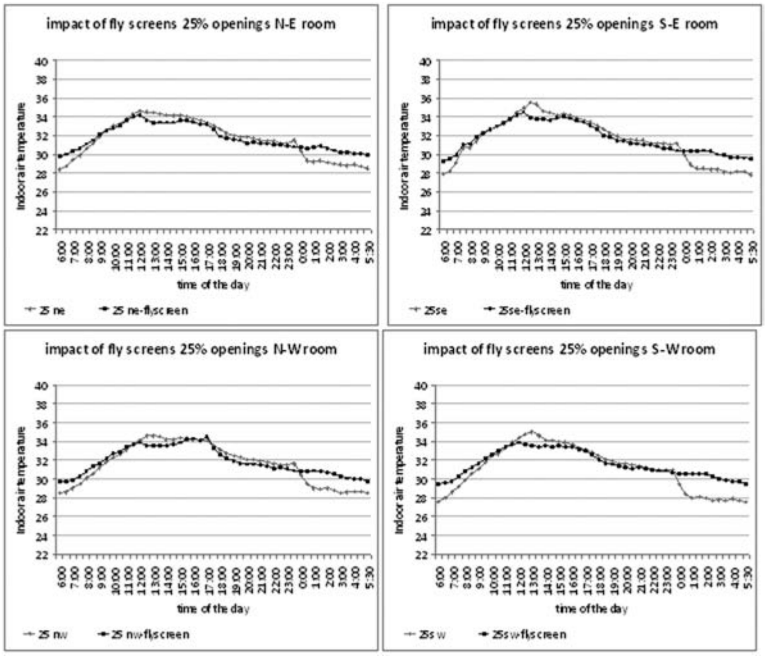

FIGURE 7. Impact of fly screens on the indoor temperature for an opening size of 25%.

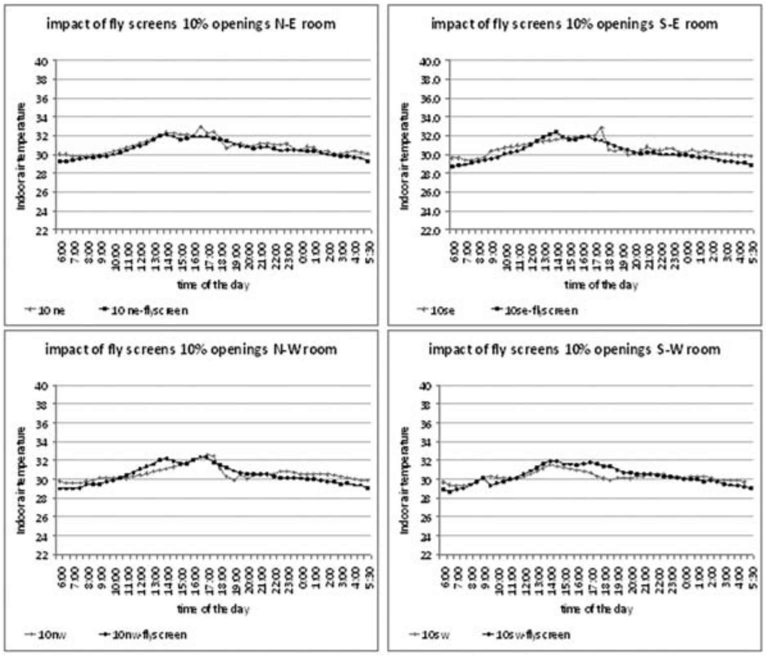

FIGURE 8. Impact of fly screens on the indoor temperature for an opening size of 10%.

TABLE 2. Impact of fly screens on indoor air temperature for varying range of opening sizes.

Opening %	Impact of fly screens
5%–30%	No difference in indoor temperature in the presence of flyscreens.
35%–50%	Indoor temperature rises by 2°C
60%–100%	Indoor temperature rises by 2°C to 3°C

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