Comparing the thermal performance of traditional and modern building in the coastal region of Nagappattinam, Tamil Nadu

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Climate has a major effect on the performance of the building and its energy consumption. The traditional houses in the coastal region of Nagapattinam, Tamil Nadu in India located in a warm humid zone represent a unique phenomenon with unique device capable to meet the comfort demand through environmental well adapted design. The traditional house and modern house in the coastal region of Nagapattinam are examined by comparing the thermal performance within the same outdoor condition and the climatic region of Nagapattinam. In this paper, a simplified thermal comparison of a traditional house with a contemporary house have been given by using only data derived from the measurements. This paper represents that the traditional houses in the coastal region of Nagapattinam provided useful indicators of appropriate architectural design response for future modern buildings.

Keywords: Thermal comfort, Traditional building, Modern building, Environment, Architecture

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Climate has a major effect on the performance of the building and its energy consumption. Reducing energy consumption, using natural resources and providing comfortable, healthier and sustainable living spaces are the aims of a climatically responsive sustainable building design. Modern housing has been criticized for its lack of response to the local environment. In many traditional buildings, both primitive and vernacular, some ingenious solutions to the architectural problems of resisting extremes of weather and maintaining comfortable indoor climate can be seen. The natural material is good for health and optimization for environmental design of building. Comparative study reveals the inner logic from the vernacular precedent. From history it has been shown that the owner of the traditional house are changing and rebuilding the design of traditional houses deserve its ability to maintain comfortable conditions for longer periods than the contemporary houses. So, it is essential for designers of coastal regions in India to take some sensitive approach to solve this problem with appropriate formal solution for future environment of the contemporary design houses.

Climate

The climate is warm-humid based on the climatic zone of India. The main monsoon is North East monsoon (October to December) contributes about 60% of the total annual rainfall. The second one is the South west monsoon (June to September) contributes about 20% of the total annual rainfall. Nagapattinam has been experiencing the hot climate in summers with humidity and pleasant climate in winters. Summers (March to May) are hot with the temperature hovering around 28 °C to 41°C, as in the coastal region the cool breeze from the sea provides reprieve from the extreme hot. Monsoon period (June to September) offer temperate climate accompanied with mild to medium rain falls. The place looks pleasing in monsoons with fresh vegetations and flowers. Winters (December to February) are pleasant with moderate climate. During winters the temperature is in a range of 21°C to 32°C. The presence of high amount of moisture in the atmosphere for major part of the year causes thermal discomfort as there is less evaporation, resulting in sweating. Temperature vary from 21°C to 41°C, relative humidity (RH) varies from 60% and will be above 90% in most of the seasons and wind velocity varies from 4m/s to 9 m/sec.
Description of the selected traditional house
The study was carried out in a selected traditional residential building located in the coastal region of Nagapattinam which is 250 yrs old (Fig. 1). These houses were built on rectangular plots mostly facing the sea coastline. The houses were generally oriented towards East West directions. A floor plan of a typical vernacular house illustrates with an outside veranda (the semi open space) in the front of the house, there are raised platforms on both sides of the semi open space called as Thinnai. There is a connecting vestibule from the verandah to the courtyard. These courtyards are meant for family day-to-day activities and ceremonial functions around which various other private spaces like bed rooms, store rooms etc is functionally arranged. In these houses a dominant axis is found from the front entrance door connecting the courtyards and corridors and ends in the rear door. This axis is mainly to allow the air to enter into the house which facilitates better air flow throughout the house. The courtyard consists of the most phenomenal wind catcher which brings ventilation (air movement) in to the house. The roof of these houses are made of country made terracotta tiles laid in 2 to 3 layers above the wooden rafters and wooden battens. These roofs are generally sloped, coupled or collar roofs with the varying heights of 3 m-4 m.

The vernacular house selected for study (Fig. 1) has a courtyard measuring 1.9 m × 1.7 m. This courtyard primarily provides light besides used as an open space for number of other activities like cooking, sleeping, working, playing, gardening, and worshipping. The courtyard of this selected house is encircled with high (3 m high) and thick (450 mm) brick walls with mud mortar and mud plaster. The average height of the room is 2.8 m.

Description of the selected Modern building
The modern building is around 28 yrs old and it is situated at a distance of 100 m from the traditional house in the coastal region of Nagappattinam. This building is a one storey (with a ground floor) detached building and it has two bedrooms with other activity spaces arranged as shown in (Fig. 2). The building envelope is reinforced with concrete structure and brick walls with plaster, reinforced cement concrete roof slab without any type of insulation. The windows are single glazed. This is considered typical of modern house being built in the coastal regions of Nagappattinam. The brick walls are 9” plastered with cement mortar. The average room height of the building is 3.4 m.

Research methodology
This research is aimed to evaluate existing passive-cooling strategies employed in vernacular buildings in the warm-humid climate of coastal regions in terms of their energy performance, thermal comfort of
occupants and cultural acceptance. And also to classify modern building types in hot humid climates by their construction and form, and evaluate their energy performance. To achieve the aforementioned objectives, relevant data and information will be collected from existing literature, through direct in situ observations and by taking measurements of case-study buildings. Case-study buildings will be chosen from a range of traditional passively-cooled and air-conditioned buildings according to criteria such as size, layout design, ventilation type, current functionality and the physical condition of the building. The climatic aspects like temperature (dry bulb temperature and wet bulb temperature), and relative humidity will be measured in one traditional buildings and one modern buildings of coastal regions from morning 6.00am to 12.00 noon for a period of two days in various seasons like summer and winter season. Finally, recommendations will be developed for applying vernacular architectural strategies to existing modern buildings, meeting the applicability, compatibility and actual requirements of people. It is hoped that the research will yield effective designs which both increase energy saving and yield maximum socio-cultural benefits. The data measurements will be used for analysis and the results obtained will be compared with ASHRAE standards to find out the thermal comfort in traditional buildings. The comparative thermal performance evaluation was made on the basis of the air temperature difference between traditional building and Modern building with the outdoor ambient temperature. The evaluation of comfort conditions is based on the analyses of air temperature and relative humidity values. The data measurements will be used for analysis and the results obtained will be compared with ASHRAE standards to find out the thermal comfort in traditional buildings.

**Thermal comfort**

Thermal comfort is defined by ASHRAE Standard 55-2004 as “the condition of mind that expresses satisfaction with the thermal environment.” The thermal environment is those characteristics of the environment which affect a person's heat loss or gain. Many studies, summarized in Olgyay (1963) have defined thermal comfort conditions. Vernon concluded that 18.94°C (66.1°F) in summer and 16.72°C (62.1°F) in winter were ideal temperatures with air movement of 50 fpm or less. Bedford stated
the ideal temperature was 18.16°C (64.7°F) in winter, and 13.22°C (55.8°F) to 23.16°C (73.7°F) was the comfort zone. According to Markham, 15.55°C (60°F) to 24.44°C (76°F) is the ideal range with relative humidity at noon between 40 to 70%. Brooks stated that British comfort zone varies between 20.55°C (69°F) and 26.66°C (80°F) with relative humidity between 30 and 70%. According to ASHRAE Standard 55-2004, a range of 24°C and 30°C is ideal for thermal comfort.

**Position of sensors in traditional and Modern building**

In traditional building the Air temperature and Relative humidity sensors were fixed outside the house and inside the room adjacent to the courtyard. In the modern building the air temperature sensors, relative humidity sensors, were fixed both inside and outside the house. Two sets of mini meterological station were installed in both selected houses to record the ambient air temperature and relative humidity of outdoor and indoor spaces. The field measurements were carried out in both houses during the same period (March 2010 to June 2010) of the hot and wet summer season in month of June. Any kind of mechanical ventilation is not allowed during field measurement.24, 26, 27

**Results and discussion**

The field measurements for the summer had been taken from mid March to June 2010, which is the predominant summer season of Nagapattinam. From the observation it was found that the ambient outdoor temperature has a temperature swing of 16.5°C, i.e. from 23.5°C to 40°C, while the indoor room temperature was varying from 24°C to 30°C showing a diurnal swing of about 6°C only (Fig.3). In the night, the indoor air temperature is maintained at around 24°C when the outdoor temperature is around 26°C. The relative humidity indoors varies from 55% to 100% (Fig. 3).when compared with ASHRAE standards it was observed that the indoor temperature falls in the comfort zone. In modern building the diurnal swing of 14°C (27°C-41°C) was observed outside and the indoor (room) temperature was varying from 28°C-36°C showing the diurnal variation of 8°C (Fig. 4). The maximum air temperature of the bedroom was about 36°C. The minimum air temperature of the bedroom was about 28°C. when compared with ASHRAE standards it was observed that the indoor temperature does not fall in the comfort zone.

From the Fig. 5 comparison of Air Temperature in traditional and Modern buildings it is observed that the minimum temperature recorded in the bedroom of traditional buildings is 25°C and the minimum temperature recorded in the bedroom of the modern building 29°C. From the Figure it is observed that the minimum temperature is increased by 4°C in modern buildings when compared to the minimum temperature of the traditional buildings. The maximum temperature of the bedroom in modern building is higher than traditional bedroom by 4°C.

Fig. 3 show that the indoor diurnal variation in the traditional building (6°C) is low in comparison with the indoor diurnal variation in modern buildings (8°C) Fig. 4. This is because the traditional building has thick walls, wide veranda, curved terracotta roof tiles, courtyards, wind catchers above the courtyards for natural ventilation. But the modern building has concrete roof, small sunshades, thin walls, small openings, etc. The reason for thermal discomfort in
the modern buildings of coastal region of Nagappattinam is due to the increase in temperature and humidity. From (Figs. 3,4,6) it is seen that the indoor air temperature in the traditional building is maintained between 24°C - 30 °C during summer with RH 75% - 60% which falls within the comfort zone as prescribed by ASHRAE standards. In modern building (Fig. 4) the indoor room temperature is maintained between 28°C-36°C with RH of 77%-50%. This is when the outdoor temperature is varying between 25°C to 40°C with RH of 95% and 42% respectively which does not fall within the comfort zone as per ASHRAE standards. Therefore, if there is no fan or Air conditioning systems the traditional building is more comfortable for longer period than the modern building within the same outdoor condition. This phenomenon is probably due to the higher cross ventilation rate in indoor spaces due to the provision of windows, wind catchers, courtyards, etc which protect the indoor living space from the direct solar radiation in traditional building. From the result of measurement it can be noted that the traditional house is comfortable from 1.00 am to 12.00 am and 2.00 pm to 12.00 pm and it lies with in comfort temperature range.(24°C to 30°C) 27 where as modern building offers the indoor comfort condition from 1.00 am to 6.00 am. The time (after 6.00 am) in modern buildings is thermally uncomfortable. When the outdoor air temperature is extremely higher than the indoor air temperature of traditional building and it tends to be lower than the indoor air temperature of modern house.

**Solar Passive features in traditional buildings**

The orientation of the building is towards east and west to bring air movement inside the building which is required for a warm humid climate. The building system with optimum window openings and the presence of wind catchers above the courtyard induces a continuous air flow inside the building.

The vernacular house has a typical unidirectional wind-catcher measuring 1.2 m × 2.1 m and this wind catcher is opening along the windward direction of the sea, which facilitates to bring cool air inside the building. The houses of courtyards with wind catchers, thick external walls, verandas, sloping roofs are clear examples of eco friendly and climate responsive architecture. In warm humid coastal region of Nagapattinam the materials with heat resistance like mud, mud-brick and brick are used which are very effective in cooling and heating of internal spaces. The use of natural and passive means in vernacular houses of Nagapattinam was very effective in providing a thermally comfortable space, which was warm in winter and cool in summer.

**Conclusion**

It is concluded that the Traditional residential buildings is thermally comfortable than the Modern building in the same surroundings. The indoor temperature is extremely higher in modern buildings then the indoor temperature of Traditional buildings with the same outdoor temperature prevailing in both the buildings. The reason for significant temperature difference between inside and outside temperatures of traditional building in summer is because of the evaporative cooling phenomena that takes place in mud mortar based traditional houses. Low thermal conductivity and less thickness of roofing and walls
of concrete based modern buildings depicts the higher temperature variations of modern buildings compared to traditional buildings. Thus it can be concluded that the solar passive features used in the traditional buildings can be used in the modern buildings in future.

References
25. Rumana Rashid, the Comparison between the Thermal Performance of a Contemporary House and Traditional House in the Dense Dhaka City in Bangladesh, King saud university - College of Architecture and Planning.