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THERMAL PERFORMANCE OF TRADITIONAL AND MODERN BUILDINGS IN KERALA, SOUTH INDIA

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Summary:

Indoor climate of Traditionally Constructed and Designed houses in India is considered better than modern buildings. The current work relates to the simultaneous monitoring of outdoor and indoor thermal conditions of the two types of buildings over a period of five months.

Both the buildings are having same orientation and are located in the same locality with almost the same micro climate and are naturally ventilated.

The traditional building which is 150 years old has tiled roof, 50 cm thick sheltered laterite walls and a 6m high ceiling. A portion of the building has been taken up for study. The rooms NR1, NR2, NR3 and NR4 of the traditional building shown in plan have been monitored for heat performance and RR1 and RR2 in the modern building.

The Modern Building which is built recently 20 years old with RCC flat roof, 30cm laterite walls and 3 mts high ceiling was also monitored in the summer season.

The work reported here deals with the first phase of a continuing study. This comprises of study under the following heads

- Monitoring the case study buildings and studying the indoor comfort conditions
- Quantifying the effect of simple passive techniques. The walls of the traditional building have been provided with shading devices such as projecting eaves and verandahs. The heat loads computed were found to be significantly less when compared to the modern building. This generated interest in quantifying the effect of sheltering the walls and roof. Hence for the modern building the heat loads are computed again by sheltering the walls and roof. The computer analysis shows the sensitiveness of the internal conditions due to these changes.

1.0 Introduction

The majority of buildings in India still incorporate natural means of light and ventilation. The energy crisis did not affect India so far as the heating and cooling of buildings are concerned, as much as it did the developed countries. But the oil crisis of the seventies did influence some Governmental and research institutions to look for alternative sources of energy and conservation. Consequently a large number of climate responsive and energy efficient buildings have been built.

It is this need which promoted the research into studying the traditional buildings to understand the features which considerably affect the heat loads.

1.1 Present study

The present study involves in evaluating the performances of a Vernacular and a modern building at Cochin in Kerala. The buildings fall in the Warm-Humid climatic zone. The buildings are located at Chottanikkara, around 20km from Cochin in Kerala. Kerala lies between 8 degree 18 minute and 12-degree 45 minute North Latitude and between74 degree 62 minute and 77 degree 24minute East longitude. The buildings are located at 9^{o} 58'latitude.

It is interesting to study those elements of a vernacular building which contribute to a better performance when compared to a modern building.

2.0 Study Area: A brief description of the study area has been given to understand the development of traditional architecture in this state of south India.

2.1 Influences on Architectural Style:

According to Sir Bannister Fletcher, the architectural style of the region is influenced by geographical, geological, climatic, religious, social and historical factors; their influences are pronounced in the case of traditional Kerala architecture.

2.2 Geographical:

Kerala is geographically isolated from the rest of India by the high Western Ghats. It had trade contacts with Phoenicia, Arabia and China from a very ancient time through numerous ports on the western seaboard. The influence of this contact is sometimes felt in the region. E.g. the characteristic upturned eaves and the gables of the southern Kerala structures are said to be the result of influence form China which had important trade links with Quilon, the most prominent port in Southern Kerala in ancient times. Influences of the Dutch, Portuguese, French and English can be seen in the buildings constructed in later period. The Provision of columned and arched openings, large glazed windows and doors, balustrades in the veranda, large staircases, increased height of structures etc. are indicative of these influences. The features of this colonial architecture were mainly restricted to the visual characteristics. The design principles of these buildings remained conservative. This shows the modification of traditional style by a particular cultural contact.

2.3 Geological:

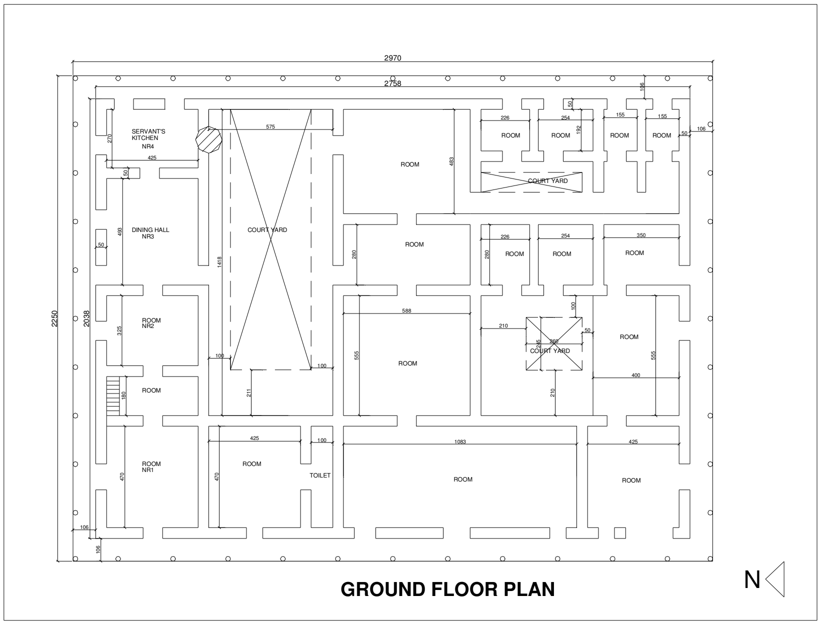
Kerala has two characteristic geological features in the habitable regions of lowland and midland. 1) Loose soil of which bearing capacity is low and 2) Hard laterite ground where bearing capacity is high. This has given rise to two different structural solutions to traditional buildings. In areas where the soil was loose, the superstructure was of framed construction. Further, to reduce the load coming over the soil, timber was used for the entire super structure, for frames as well as for infilling. The structures were invariably single storied.

2.5 Climate: The study region lies in the subtropical belt. There is a long and heavy monsoon season stretching from June to December with a month's break in September – October. Both southwest and northeast monsoons strike the region with full force. Average rainfall is 3000 mm. The temperature variation, both diurnal and annual, is very low (around 10° C maximum). Humidity is very high throughout the year, normally over 80%, and reaching saturation point during the rains. The above climatic conditions have necessitated high pitched roof with wide overhangs and low eaves, and structures single bay wide with open verandas around. When more built spaces are required, it is always provided with courtyards. The alteration of open and built spaces with steep pitched roof, wide veranda, low eaves etc. have resulted in the unique architectural style of the region.

3.0 Plan and front elevations of the traditional building

Front elevation of the traditional building   central court yard


Ground Floor plan of the traditional building



Plan and front elevation of the modern building

3.1 Features of the traditional building:

The traditional building has tiled roof with 6 mts high ceiling. Only NR1 has a mezzanine floor. The walls are constructed of laterite a locally available material and are 50 cm thick. The building has 3 court yards.

3.2 Features of the modern building:

The roof is of Reinforced cement concrete with 0.15m thick and the ceiling height is 3 mts. This building doesn't have courtyards.

4.0 Analysis

It is important to understand the features of the buildings and the landscape which mainly influence the thermal comfort.

4.1 Building Envelope

4.1.1 Type of roof: Traditional building has tiled roofing. The portion of the building studied has ridge line running east west and the roof slopes to the north and south. The whole Roof is not exposed to sun at the same time whereas in the modern building the flat roof is exposed to the sun throughout. The Modern building gets heated up and stores heat because of high thermal mass as compared to the tiled roof building. The trend shows that the inside temperature in the modern building is high extending even up to midnight. The Tiled roof-building cools down much faster resulting in higher comfort during nights.

4.1.2 Color and Texture of walls: In the traditional building the walls are painted light blue in color. The walls have rough texture. In the modern building the walls are smooth and painted dark pink. Light colors reflect radiation whereas dark colors absorb radiation. Rough texture causes self-shading of walls. This is one of the reasons for low temperature in traditional building.

4.1.3 Landscape/Vegetation: The surroundings have dense vegetation all around with lots of tall trees and rubber plantations except in the front façade in both the buildings. The remaining area is thickly vegetated. The entire area has similar nature of vegetation.

4.1.4 Water bodies: The compound has several large water bodies. In this compound there are four natural ponds, one very large and the other three small. The large water body is very near to the rooms studied in traditional building. This is one of the reasons for high humidity in traditional building.

4.1.5 Orientation: Both the buildings are oriented north south. The longer axis of the buildings faces north south.

4.1.6 Openings: In the traditional building the percentage of openings on the west facing side is11 and on the North facing side is 9.2. In modern building on the West Side it is 14.2 percent and on the north side it is 7.82 percent. The percentage of openings is more in the modern building. So the radiation is also more in modern building. The fenestration is completely shaded in traditional building with deep overhanging eaves whereas in the modern building they are shaded with horizontal sunshades of 0.6m width.

4.1.7 Plan form: Heat gain or loss depends on the surface volume ratio(s/v). If the surface volume ratio is small heat gain or heat loss is less. For traditional building s/v ratio is 0.15 and for modern building it is 0.28.Compared to RCC building the s/v ratio is smaller for traditional building so the heat gain or loss is less.

5.0 Data collection and analysis of data

During the study temperature and humidity were recorded using simple thermometer and hygrometer. They were positioned in the center of all the rooms taken up for the study. The readings were recorded from 9 AM to 5 AM at 2 hours interval for a period of 5 months (December to April). The outside conditions were also monitored at the same interval. The outside instruments were positioned 2 feet from the external wall so that it was shaded at all times of the day by the projecting eaves.

The method adopted to reduce the vast quantity of data collected was to look for the peak day time condition outdoors and to compare this with the indoor temperatures and humidity levels at the same time.

Tables 1 and 2 show the temperature data for the traditional and the modern building during the month of April. T_{out} represents the outside temperature. In table 1 $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ represent the indoor temperatures in NR1, NR2, NR3 and NR4 respectively of the traditional building. In table 2 $T_{1,}$ T_2 represent the indoor temperatures in RR1 and RR2 of the modern building. ΔT represents the difference between outdoor and indoor temperature in both the tables.

As can be seen in table 1 the value of ΔT varies between 3 to 5 degrees centigrade in the traditional building whereas in the modern building the value of ΔT varies between 1 to 3 degrees.

Table1 April - traditional building

Time	T_{out}	T_1 NR1	ΔT DIFF	T_2 NR2	ΔT DIFF	T_3 NR3	ΔT DIFF	T_4 NR4	ΔT DIFF
9:00AM	32.4	29.3	3.1	28.9	3.5	29.2	3.2	29	3.4
11:00A	33	29.7	3.3	29.5	3.5	30.4	2.6	30.6	2.4
1:00PM	37.1	31.3	5.8	30.9	6.2	32.4	4.7	31.8	5.3
3:00PM	36.2	31.7	4.5	31.3	4.9	32.3	3.9	32.3	3.9
5:00PM	32	31.5	0.5	31.8	0.2	31.5	0.5	31.4	0.6

Table 2 April- modern building

Time	T_{out}	T_1 RR1	ΔT	T_2 RR2	ΔT
9:00AM	32.4	29.3	3.1	29.5	2.9
11:00AM	33	31	2	31.4	1.6
1:00PM	37.1	33.7	3.4	34.8	2.3
3:00PM	36.2	33.5	2.7	33.3	2.9
5:00PM	32	32.9	-0.9	33.6	-1.6

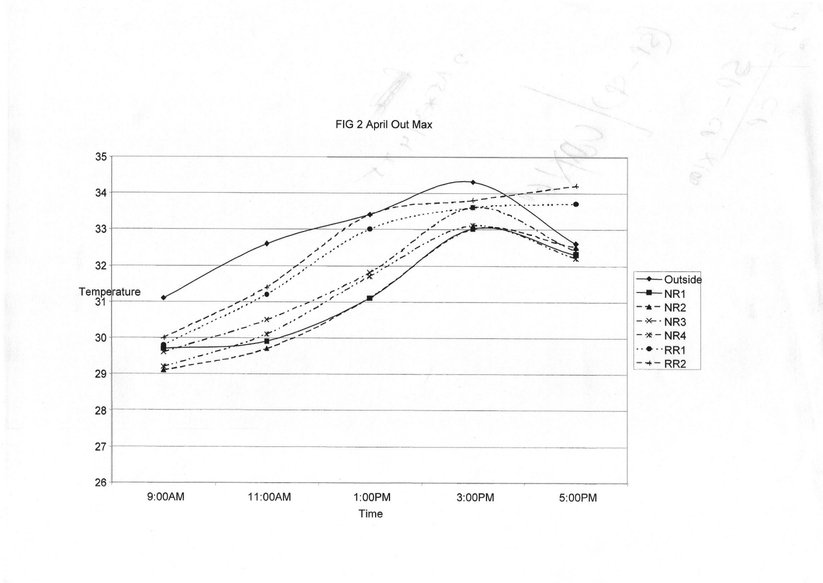
The current study focuses on thermal performance of the building. Table 3 discusses the ranking based on dry bulb temperatures only.

Table 3 Rank order of best to worst thermal performance-Summer

Time	Rank order of Thermal performance (From best to worst)
9:00AM	NR2>NR3>NR4>NR1,RR1,>RR2
11:00AM	NR2>NR1>NR3>NR4>RR1>RR2
1:00PM	NR2>NR4>NR1>NR3>RR1>RR2
3:00PM	NR2>NR1>NR3>NR4>RR2>RR1
5:00PM	NR4>NR3,NR1,NR2,RR1>RR2

Graph 1 shows the temperature in all the rooms during the month of April.

GRAPH 1



6.0 Heat load calculations:

The heat loads are calculated based on "Carrier" air conditioners hand book. Heat transfer in buildings takes place from the building envelope due to conduction (through walls, roof and glass) radiation (through glass windows) and internal heat gains due to people, equipment.

6.1 Sample calculations of heat loads.

Table 4 shows the heat load calculations for RR1. The heat loads due to conduction, radiation and internal heat gains are calculated. Heat loads due to ventilation are not applicable as this building is naturally ventilated. The U value for partition walls and for all the external walls is calculated separately. The solar radiation values on April 16th at 3 PM were taken from hand book on climatic data published by CBRI Roorkie. At any point of time it is assumed that there are 3 people in the room and one bulb is switched on.

The walls of the traditional building are under shade through out the day as the projecting eaves cover the walls. Hence the difference between outdoor and indoor temperature is taken equal as ΔT for the traditional building. Effective temperature also known as sol-air temperature is taken when the walls are exposed to solar radiation. The walls and roof of the modern building are not shaded. Hence for RR1 and RR2 effective temperatures are taken. The values are taken from the book Refrigeration and Air-conditioning by CP Arora.

In RR1 only the west wall is exposed to sol air whereas all other walls are partition walls. The roof is also exposed to sun hence effective temperatures are taken for both roof and the west wall.

Table 4 Heat load calculation for RR1

1.conduction	Area A SqM	U value	Temperature difference ΔT	Heat loads $A*U*\Delta T$
North wall	11.4	2.1	0.8	19.152
East wall	14.43	2.1	0.8	24.24
west wall	12.99	2.76	10.85	389
South wall	11.4	2.10	0.8	19.152
Roof	18.28	3.35	25.65	451.5
Glass	1.44	5.67	0.8	6.53

2.Radiation	Area A	Solar Radiation I (W/sqm)		A* I
West wall	1.44	470		676.8
3.Internal heat gains		Heat emitted		
No of people	3	160		480
Lights	1	60		60
Equipment	Ventilation rate V			1300*V*ΔT
			TOTAL LOAD	3245 W

6.2 Analysis

Table 5 shows the heat loads generated in all the rooms of the traditional building and the modern building. These heat loads are calculated on April 16 at 3 PM.

The table shows the volume of each room and the heat load generated.NR1 has a mezzanine floor. Hence heat loads are less in NR1 when compared to all the other rooms as the roof is considered to be shaded. The heat loads are dependent on the volume of the building.

Table 5 shows that the heat loads are high in RR1 and RR2. The heat transfer is maximum through walls and roofs. The main features of the traditional building are that the walls are shaded. This generated interest to find out the effect of shading walls and roof.

Heat loads are calculated again by assuming the walls and roof to be shaded in the modern building. Due to this the heat loads are reduced by 40 to 50 % when only the walls are shaded and around 80 % when both the roof and walls are shaded.

When the modern building is shaded the heat loads in rooms RR1 and RR2 have almost the same heat load as NR1 which has the same volume.

Table 5

Room	Volume M^3	Heat Loads Watts	Heat Loads When The Walls are Shaded	Heat loads when Walls And Roof are Shaded
NR1	59.22	791	-	-
NR2	100.62	1464	-	-
NR3	137.59	1405	-	-
NR4	86.58	1761	-	-
RR1	54.72	3245	1548	561
RR2	59.28	3773	2337	692

7.0 Conclusions:

The traditional building has low indoor temperatures when compared to modern building. It was found that the NR2 has the lowest indoor temperature most of the day and RR2 the maximum temperature. The reason is that all the walls are shaded in the traditional building. The portion of the building studied has ridge line running east west and the roof slopes to the north and south. The whole Roof is not exposed to sun at the same time

It is important to quantify the effect of each building element for a better understanding of heat transfer in buildings. An attempt was made to study the effect of shading of walls and roofs. This study conclusively proves that the major contribution to heat transfer is through building fabric. As computed the heat loads reduce by 50 % when only walls are shaded and around 80% when the roof also is shaded.

During the case study it was found that though temperatures are low the interiors are not comfortable as the ventilation is poor. During the study it was found that the Anemometer based velocities were found to be very less when compared to 1 m/sec provided by local weather station. This preliminary study is focused on the thermal performance of the buildings. However it was found from the bio climatic chart that a wind speed of 0.4 m/sec to 1 m/sec brings comfort level in both the buildings.

An extensive study is required to quantify the affect of court yards. Computational fluid dynamics techniques need to be studied in detail to understand the air flow movement to study the optimum size of the courtyard.

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