Thermal Comfort of Bangladesh Traditional House In A High Density Environment with the Worst Surroundings Condition in Dhaka City.

A case study at a Bangladesh Traditional House at Gulshan in Dhaka City.

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Abstract

Bangladesh traditional house is a typical example of dwelling which encapsulates the socio-cultural values of the country and traditional form. Bangladesh traditional houses was a good representative of warm humid tropical houses that can well-adapt to local climate and well collaborate with a local believe and tradition as well as local materials. Highly dense worst surrounding condition of Dhaka city have impact to the quality of indoor and outdoor climate, it influence to the thermal comfort in the traditional house. The question is how Bangladesh traditional house can contribute in providing the thermal comfort in a dense environment. Quantitative method is used to measure the thermal performances. The field survey was conducted using thermal data loggers. A set of thermal data loggers were installed in selected Bangladesh traditional houses in Dhaka to record the air temperature and humidity of the indoor, outdoor and upper spaces. Data collection was carried out for duration of two months in winter and four months in summer. The research result was obviously the original Bangladesh Traditional house still has a better ability in providing the thermal comfort especially in a dense environment at Dhaka city in Bangladesh. The use of the upper space in Bangladesh tradition house has significant impact on the overall indoor thermal comfort. It is proved on the condition of indoor air temperature that can be categorized in comfort zone. Thus, modern houses should consider employing this upper space to achieve thermal comfort.

1. Introduction

Traditional architecture is culture of the society. It reflects inhabitants' life style and traditional heritage of the country. It possesses distinct characteristics with regards to planning, use of materials and location. Like urban architecture, traditional house is also subject to change but in Bangladesh the traditional houses have clung to tradition. It has not really changed until recently. The full planning concept has been developed by the local people according to demand of their lifestyle. Dhaka being the capital of Bangladesh is the most important city of the country. The city now accommodates nearly 6 million people (Population Census 2006) on an area of 815 square kilometers. So the population density of Dhaka is about 8251 persons per square kilometer. According to Climatologists, the growths have created numerous micro-climates in some areas in Dhaka city. It is obvious that such changed microclimates can affect the microclimates inside the adjacent traditional house. The impact of solar radiation affects the thermal behavior of roof more than any other part of the house especially in tropical countries (Mallick, 1993). In Bangladesh, most of the roofs are exposed to direct solar radiation, and which elevates the indoor temperature above the local indoor comfort level (24K to 32K by Mallick, 1993) in summer seasons (Abul Mukim Mridha, 2002). Mechanical cooling is a very expensive (per unit 3.5 taka) option in the Bangladesh. In such a context, developing passive means of the solar control is important for comfortable living and higher productivity during summer season of the year. Traditional houses are designed by the owners according to demands and are based on low investment, rebuiltable structure and use of local materials (Rumana, 2007). On the other hand, from user experience, traditional houses of Bangladesh are less hot during the daytime, but it becomes comfortable within a short time after sunset. Therefore, the question arises on how the traditional house of Bangladesh can afford to control natural climate for achieving thermal comfort environment in the indoor space. This is the main issue that influences this research.

1.1 Research Hypothesis

The hypothesis of this study is that the upper space of the traditional house in Bangladesh will achieve the following:

1. The thermal performance of traditional house in Bangladesh is influenced by the upper space during winter and summer seasons.

2. By controlling the wall openings of the upper space of the traditional

house, indoor occupant space can achieve thermal comfort environment within the context of the dense Dhaka city.

1.2 Research Questions

The following questions will be addressed in this research:

1. How upper space plays a vital role with diurnal variation of ambient environment?

2. What is the thermal performance of traditional house in Bangladesh which is influenced by the upper space during winter and summer seasons with different percentage of window openings?

3. Does the traditional house provide thermal comfort in context of dense environment of Dhaka city?

1.3 Research Objectives

The aim of the study is to investigate the thermal performance in Bangladesh traditional house roof section in the context of an uncomfortable dense environment of Dhaka city with the following objectives:

1. To evaluate the thermal performance of the Bangladesh traditional house.

2. To study the influence of upper space of the traditional house on the indoor thermal performance during winter and summer periods.

3. To study the effect of window openings at upper space, on the room thermal performance.

4. To evaluate the potential role of upper space with different percentage of window openings and how they influence the indoor thermal environment.

1.4 Scope and Significance of the Research

The scope of research is to investigate the thermal performance of the traditional upper space and the changes that occurs in the indoor thermal environment with diurnal variation of the room during summer and winter seasons. The significance of the research depends on the understanding of the thermal performance of traditional house in Bangladesh in the context of dense Dhaka city. This research establishes a number of casual relationships between the traditional houses design component with various micro-climatic factors. Hence by adopting the appropriate design strategy, modern houses can be effectively

designed towards sustainable urban environments. This research study helps to develop the practical design guidelines for the modern house design. The micro-climatic study of the traditional houses conducted in dense Dhaka city, indicate the difference that exists within the larger context of the urban climate.

2. Climate of Bangladesh: Classification and Outline

In terms of ecological region or biomes described by UNESCO (United Nations Educational, Scientific and cultural Organisation) (Lean 1990) Bangladesh, lying between 20º34′ N to 26º33′ N and 88º 01′E to 92º 41′E, is in the Indo-Malayan Realm. The climate of Bangladesh based on the widely used classification by Atkinson (Koenigsberger, 1973). Climatic variables are shown in table 1.

Table 1: Classification of the seasons and climatic variable in Bangladesh.

Meteorological Seasons	Gregorian Calendar Months	Ave. air Temp For 91-00 (K)	Mean RH For 91-00 (%)	Mean Rainfall For 91-00 (mm)	Mean Wind Speed & Direction For 91-00 (m/s)
Winter (cool-dry)	January	18.8	72.4	11	1.4(NW)
Winter (cool-dry)	February	21.9	67.0	27	1.9(N)
Pre-monsoon (hot-dry)	March	26.6	63.6	69	2.4 (SW)
Pre-monsoon (hot-dry)	April	28.9	70.9	120	2.9(SW)
Pre-monsoon (hot-dry)	May	29.0	78.4	342	2.4 (S)
Monsoon (hot-wet)	June	29.5	82.3	267	2.3 (SE)
Monsoon (hot-wet)	July	29.1	84.0	371	2.2(SE)
Monsoon (hot-wet)	August	29.2	83.6	335	2.2(SE)
Monsoon (hot-wet)	September	29.0	83.5	293	2.1(SE)
Post monsoon (hot-wet)	October	28.0	80.7	197	2.1(N)
Post monsoon (hot-wet)	November	24.5	75.7	26	1.3(NW)
Winter (cool-dry)	December	20.3	74.4	13	1.6(NW)

3. According to Climatic Zone Different regions in Bangladesh have Different Type of Traditional House Design

The traditional house in rural areas of Bangladesh offers a fine example of culture, region specific social product. (M.A. Muktadir et al, 1985). Bangladesh is located in subtropical monsoon region. There are widespread differences in the intensity of the seasons at different places of the country. On the basis of entire climatic conditions, Bangladesh can be divided into the following seven distinct climatic regions (figure 1). According to climatic regions, different types of traditional houses were developed in different zones. Detail description are available in “Traditional House of Bangladesh: Typology of house according to materials and locations” (Rumana Rashid, 2007).

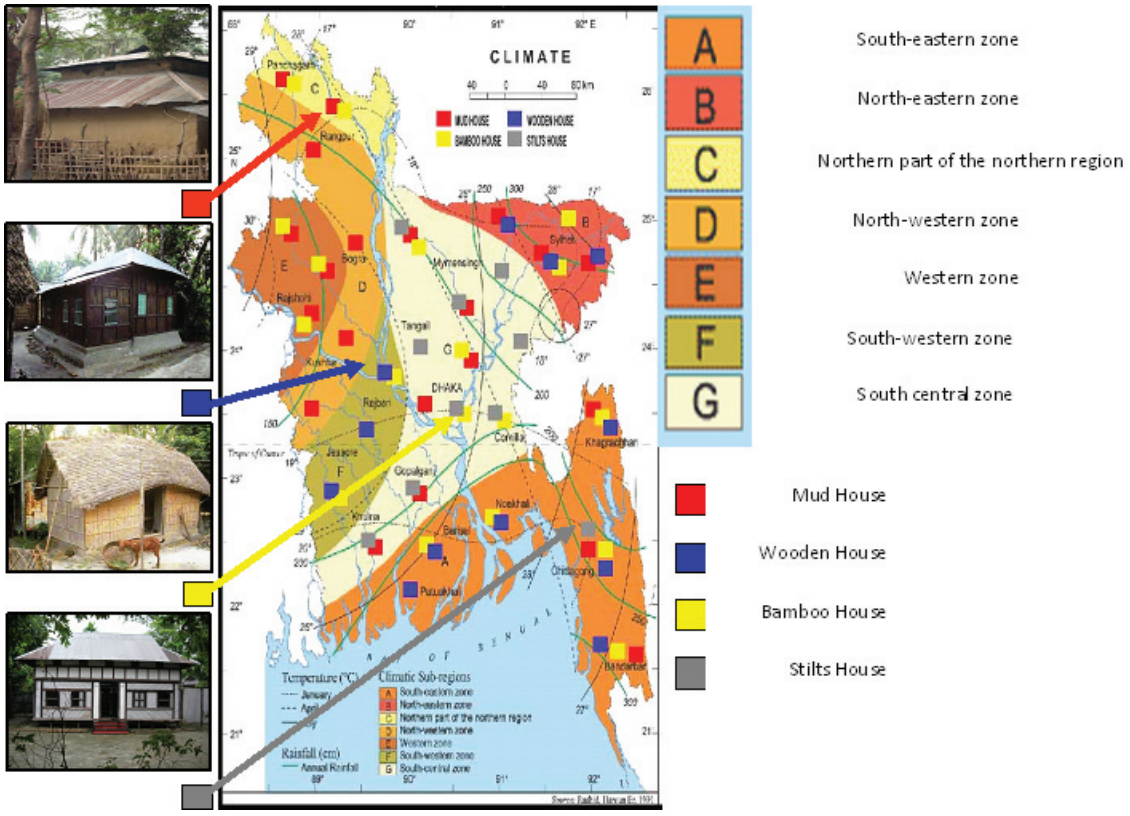


Figure 1: The different type of traditional houses of different region in Bangladesh

4. Literature review

Researcher	Research Title	Findings
Mehdi S. 2006	The Traditional Elements of Malay Houses	The bumbung panjang is the best form suited to climate
Rosalia,2006	Natural Design For Tropical Archipelago Lowland, Madurese Traditional Houses	Principle of natural design is found
Cai Hui and Li Xiaodong, 2006	Vernacular President Adaptation in Sustainable Architecture Design in Tropical Regions	Interrelationship between performance and morphology to understand sustainability
Teow Ngak Ng and Hsien-Te Lin, 2006	An Analysis on Microclimate of west Sumbanese Vernacular Architecture	Middle part of the house is comfortable
Poomchai Punpairoj, 2006	Influence of Changing Use of Materials on Thai Venacular House Construction	Design guideline and conservation plans
Nur Endan Nuffida, ST, MT, 2006	Interpeting Vernacular Architecture: A Challenge Method for understanding Building	Neovernacular can serve conception of dwellings in future
Laksmi G. Siregar, 2006	Local Material Which Influence The Traditional House Form Against the Tropical Climate, Toraja, Indonesia	Toraja house is comfortable in tropical nature

Fx Teddy B. S, 2006	Thermal Performance of Kloneng As Local material on Javanese Village house	Wall optimization can be obtained as alternative and contribution for environmental design
B. Heru Santoso, 2006	The Thermal Comfort Of the Javanese Traditional House In a High Density Environment	The Javanese traditional house is comfortable**.**
Dilshan, Hamdan, 2008	Thermal Performance of Prototype Malaysian Traditional Timber House	Timber house internal and external air temperature is similar

5. The Reason of Selection of the particular type of house for this Research

By general comparison between rural and urban houses, it is evident that rural houses are extensively protected from effects of solar radiation by trees, which produces its own microclimate. Traditional built forms of the rural area often includes sound solution for climatic problems. The temperature difference between rural and urban areas is 4K to 5K (Mallick, 1993). In urban areas, the construction activities associated with urbanization appear to increase the radiation of heat. For this reason Dhaka city is selected as research area and which strongly justifies the study of the thermal performance of the traditional house in its worst condition in the highly dense area. According to climatic zone, Dhaka is situated in the south-central zone. Flood occurs every year in this zone. So the typology of the stilts house which is elevated from the ground level is more durable in this zone. The materials used for different types of traditional houses in Dhaka city indicate that the percentage between materials of roof are, straw/ bamboo 13%, tiles/C.I. (corrugated iron) sheet 60% and cement/flat roof 27% (Bangladesh population census, 1997). Therefore, the percentage of the stilts house is higher than other types of traditional house in Dhaka. So in Dhaka the stilt house is the most popular traditional house. These are the reasons to select the stilts house.

6. Methodology of the research

The field study deals with the thermal performance of traditional Bangladesh house with the special reference to Dhaka. The methodology of the fieldwork employed to study the effectiveness of the traditional house upper space and its influence on the overall thermal performance of the selected traditional house.

6.1 Selection of the Particular House for Field Study

The primary criteria for the selection of the selected house are as follows,

• Traditional house is effectively designed to establish approach towards sustainability of worst urban environment. So the selected house which is selected for this research is situated in the urban context in Dhaka city at highly dense Gulshan area.

• 53 years ago this house was built in rural area (Maowa, in Bangladesh since 1955). In 1975, when the owner migrated to Dhaka city, he brought this one unit house and rebuilt it at Gulshan area. So there is no doubt that this particular selected house is the most appropriate as an example of traditional house, which have all features of the traditional houses in Bangladesh.

6.2 Impact of the surrounding

The selected house is densely surrounded by other traditional houses (figure 2). According to Ahmed (1995) Air temperature, air humidity and wind velocity varies depending on the density of the surroundings built forms. Wind velocity does not affect the indoor air temperature because of high density of the built forms. Highest wind speed occurred in April 2.9m/s while lowest was November 1.3 m/s. The prevailing wind direction was the same as for last thirty years. Urban, suburban and rural relative humidity exhibits a marked diurnal variation and generally decreases towards city center. During the afternoon in the dry seasons the difference may be as high as 12% (Ogunloyinbo, 1984) and night temperature difference can be as high as 13% in the same seasons. Rapid urbanization after 1980 plays a vital role in the reduction of wind speed in Dhaka

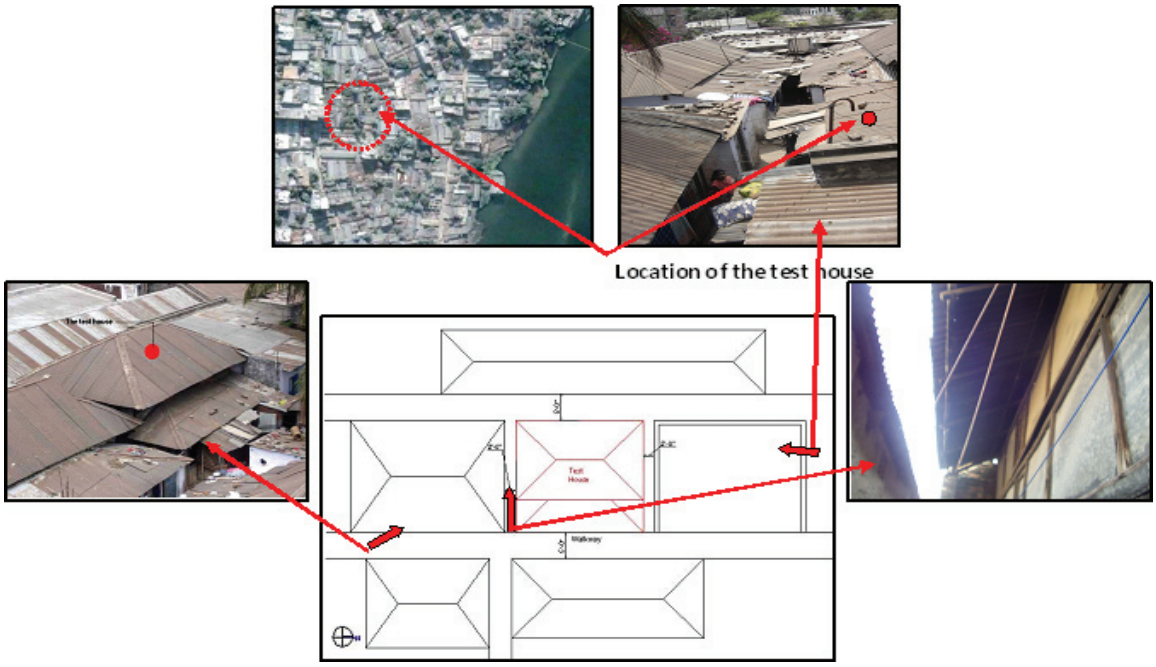


Figure 2: The site and surroundings of the selected house and distance from other houses

city (Sabbir, 1995). According to the above consideration, it is identified that the wind speed does not affect the thermal performance of the traditional house in this dense surroundings. Indoor cross ventilation does not work successfully in the selected house because of dense surroundings.

6.3 Description of the Selected House

The selected house is surrounded by similar type of traditional house on the north and south side at respective orientations. The west and east sides (figure 3) are facing 1.5m road.

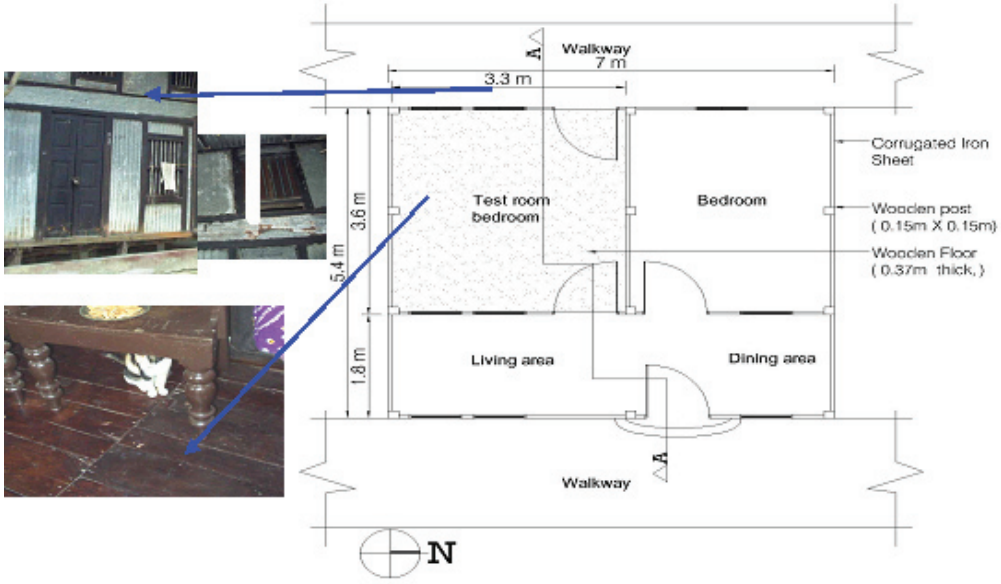


Figure 3: Plan and construction material of the selected house

For recording indoor climatic variables, the bedroom was selected which is occupying the southwest corner of the house. This is the hottest corner of the house according to user experience. The selected room (figure 3) receives solar radiation for a longer period compared to other two rooms and also from a study of Sharma (2002), he found that the relation between hot category rooms and cardinal locations, the west side room took the highest position and southwest room took the second highest position in Bangladesh. This research selects the worst corner of the selected house to justify the thermal performance of the traditional house in Bangladesh.

The room height is 2.8m. The size of the bedroom is 3.3m wide by 3.6m length (figure 3). This room has two windows of 1m wide on west and east side periphery and two doors. This room is connected to living area through a door (figure 4). Walls are made with 150mm by 150mm wooden post and corrugated sheets. The ceiling is made of 37.5mm thick wooden planks with 125mm by

75mm wooden beams. Furniture of the room consists of a wooden double bed, wooden wardrobe, wooden cabinet and a wooden study table with chair. The floor is raised from the ground and made by wooden planks. There are two 60 watt florescent lights (one is regularly used and the other is occasionally used) and one ceiling fan in the test room.

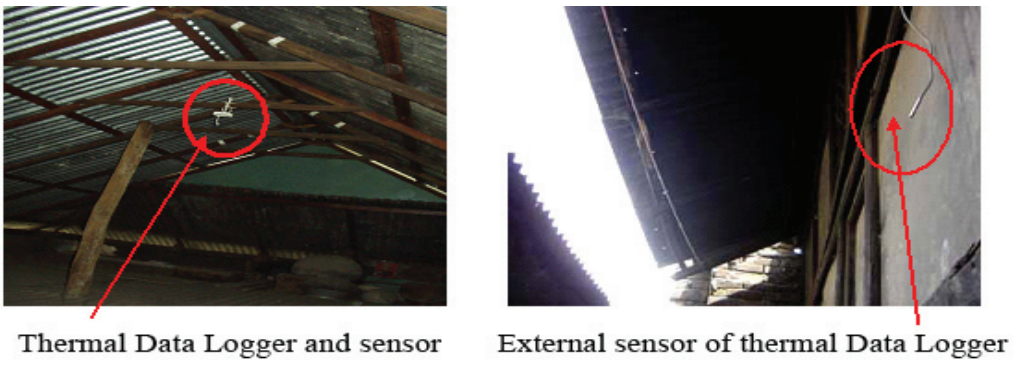


Figure 4: Interior of the selected house

The outer surface of the upper space is made of corrugated iron sheets. It is directly exposed to the sun. The extended roof protects the windows of upper space from sun and rain. The upper space has four windows on west and east wall, which are 1.25m by 1m wide. The window of north and south side of the upper space is closed. The floor of the upper space is of wooden planks. In this area there is an incandescent light, which is used occasionally. Generally upper space is used as a store.

6.4 Instrumentation and Experimental Procedure

Thermal Data loggers were installed in the selected house (figures 5,6) for collection of air temperature and relative humidity data in the three zones, namely upper space, indoor living space and outdoor of the house. The remote data loggers recorded data with the help of external sensors. Data were recorded



Figures 5: Thermal Data Logger position in upper space (left) and placement of external sensor under shade of extended roof of the house (right)

at interval of every five minutes. The controlling software assigns range of the logger interval. The loggers are initiated by software Box Car Pro 4.0. The software is required for the downloading of data from the data loggers and in making the graph; and exporting data to excel file. Excel software also used for data analyses.



Figure 6: Thermal Data Logger position in upper space (right); Entry from indoor space to upper space (left); Wooden ladder for entering to the upper space (middle).

The instruments used in this field study were as follows

Thermal Data Logger (HOBO H08-007-02)	2 Nos.
External Sensor TM C6-HA	3 Nos.
USB cable	1 No.

Installations of the Thermal Data Loggers are as follows and show in Figure 7.

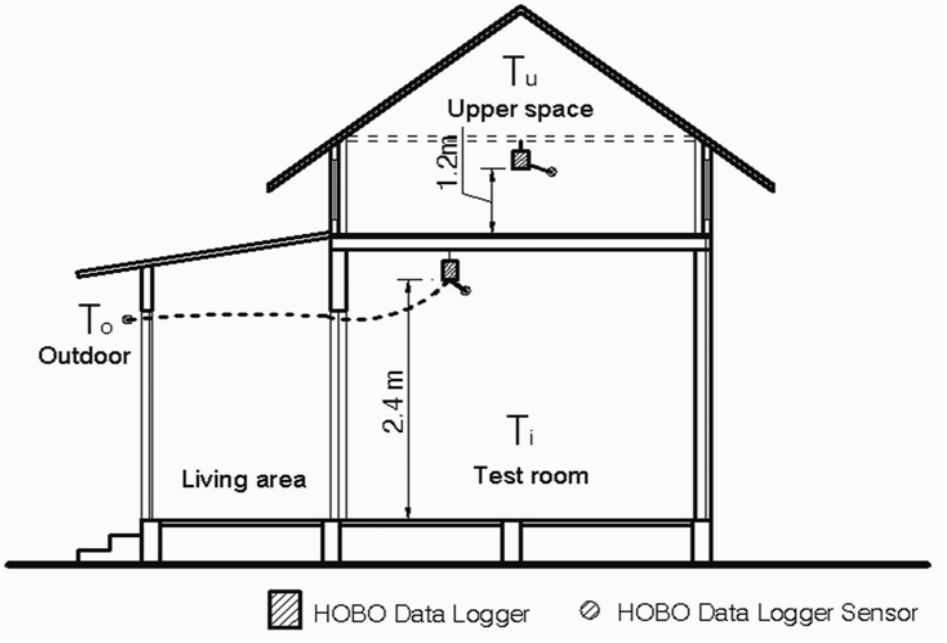


Figure 7: Thermal Data Logger position in indoor, outdoor and upper space in section of the selected house

No	Position and Description	Measured Variable
1	Upper space, 1.2m from upper floor	Air Temperature and Humidity
2	Indoor living space, 2.4m from floor	Air Temperature and Humidity
3	Outdoor environment	Air Temperature and Humidity

6.5 Data Collection Method

The data of the field study was taken during the most persistent and dominant seasons; winter and summer. At the same time the most extreme climatic value are also registered during these periods. From previous study it was identified that January is the coolest month and April is the hottest month for Bangladesh. The mean maximum temperature over Dhaka has its lowest value in January and progresses as the season progresses. It becomes maximum temperature in April with a decreasing tendency up to August. The mean temperature increases from January to April, then remains almost constant up to September, and decreases up to January. The mean minimum temperature is the lowest in January, increases up to June and remains fairly constant up to September and decreases after that (Karmokar et. al, 1993). Winter period in Bangladesh is from December to February but only for three months. For this reason, in this research the field study was carried out in winter in the month of January and February. For the long summer season the selected month was March to June because April to September remained almost constant. Climatic variable were collected using thermal data loggers and sensors for duration of six months. To verify the air temperature of Dhaka city, five days data was taken per minutes and was found that within eight to ten minutes air temperature had not changed significantly. For this reason data logger has been programmed to collect data for every five minutes interval. With this interval, the loggers set for seven days and 2030 temperature and humidity data. The data was downloaded after six or seven day's intervals. Data collection started from 10 January 2007 and it was continued up to 20 June, 2007. Further, in order to analyze the thermal performance the following methods were used for data collections (table 2). The percentage of opening of the upper space is different in different months. Observation on environmental factors relate directly to thermal performance of the indoor environment are air temperature and relative humidity.

Table 2: Tabular output method of Climatic data collection for the test room of the traditional house

Season	Month	Date	Collected Data (Air Temperature)			Indoor Relative umidity	Opening of window in Attic
			Indoor (Ti)	Upper Space (Tu)	Outdoor (To)		
Winter	January	10th to 31st	Ti	Tu	To	Rhi	0%
	February	1st to 28th	Ti	Tu	To	Rhi	0%
Summer	March	1st to 31st	Ti	Tu	To	Rhi	0%
	April	1st to 30th	Ti	Tu	To	Rhi	25%
	May	1st to 31st	Ti	Tu	To	Rhi	75%
	June	1st to 20th	Ti	Tu	To	Rhi	75%

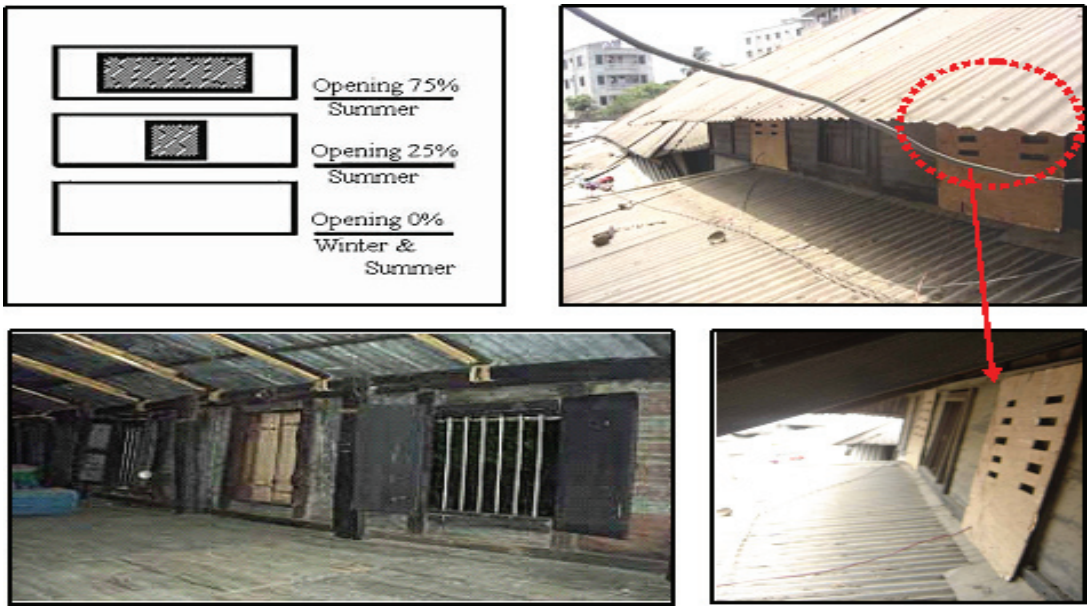


Figure 8:Window opening 25% of the upper space during construction (right) and 75% window opening (left bottom).

7. Result and Analysis

The purpose of this paper is to discuss the influence of the design strategy on the thermal performance of the Bangladesh Traditional house. The results are analyzed by comparing the internal and external temperature of the three zone identified, namely upper space, indoor space and outdoor. A comparative study was made to judge the thermal performance of the traditional house during summer and winter season with respect to thermal comfort temperature range. The performance evaluation was made on the basis of temperature difference between indoor, outdoor and upper space (Ti= indoor temperature; To= outdoor temperature; Tu= upper space temperature) with comfort zone

analysis (according to Sharma ,Ali and Mallick for winter season is 17°C to 32°C and for summer is 24°C to 32°C). For thermal performance evaluation is made with daily maximum and daily minimum air temperature is preferable for this research because daily maximum temperature is the highest value for day time and daily minimum is the lowest value in night time temperature value.

7.1 Comparison of internal and external air temperature for winter season without any window opening in upper space

From figure 12 the temperature profile represents the outdoor temperature at night became cooler than the upper space temperature and indoor temperature is higher than the outdoor and upper space air temperature. According to air temperature difference, the relationship between outdoor, upper space and indoor indicates that, during day time Ti<Tu<To and at night time Ti>Tu>To. At night the average minimum air temperature difference between indoor and outdoor was 18.45% compared to outdoor range. Upper space becomes hottest in 3pm. So during day time the closed windows of the upper space, worked as a buffer in winter seasons, which gain heat from outdoor and store the heat for a long time and transmit heat into the indoor living space after sunset. At night time when people stay in their houses, the indoor environment is warmer than outdoors which is desirable during winter seasons. During the day time, the outdoor temperature is higher than the upper space and indoor temperature. But indoor living space and upper space air temperature still remains within comfort range 17°C to 32°C (Sharma and Ali). For better thermal environment in indoor living space during winter periods it is recommended that window openings, of upper space need to be closed throughout the winter seasons.

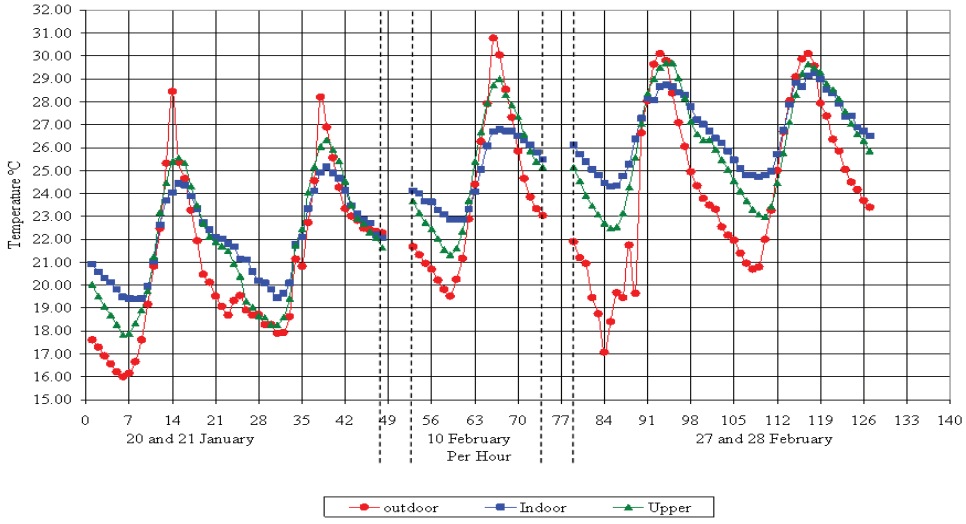


Figure 9: Profile of indoor, outdoor and upper air temperature in common weather condition of the test room without window opening in the upper during winter season for selected days

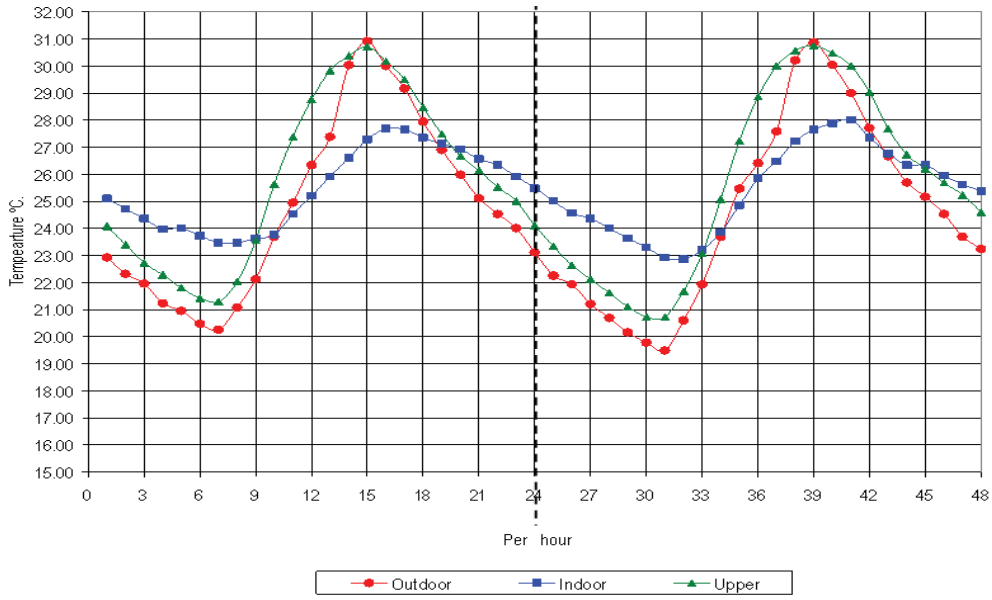


Figure10: Profile of indoor, outdoor and upper air temperature of the indoor without window opening in the upper space for selected days

7.2 Comparison of internal and external air temperature for summer season without any window opening in upper space

From figure 10 the temperature profile of indoor, outdoor and upper space indicates that the upper space air temperature was little bit higher than the outdoor temperature at day and night time. From figure 10 the upper is 3°C higher than the indoor but almost same with the outdoor air temperature during day time. Assumption about traditional house without upper space, the indoor living space temperature will be higher than the outdoor temperature. At night the average minimum air temperature difference between indoor and outdoor was 16.75 % of outdoor range. During day time, the average maximum air temperature difference was 11.08 % of the outdoor range. During summer season without window openings of upper space during day time only shows the effectiveness in maintaining the thermal comfort environment of the indoor environment. But at night, it creates undesirable conditions in the indoor living space. Due to the hot trapped air in upper space, heat is transmitted into the indoor space. Therefore, there is no potential of cooling immediately at night time. The relationship between indoor, outdoor and upper space at night is Ti<Tu>To and in summer day time is Ti < To. This is a desirable condition for comfort environment in summer day time. Upper space is influenced by solar radiant temperature, as it obstructs the major passage of incoming heat through the upper space to the indoor space and help to reduce solar radiant temperature to ensure thermal comfort in indoor living space of the Bangladesh traditional house.

7.3 Comparison of internal and external air temperature for summer season with 25% and 75% window opening in upper space

From figure 11 the upper space temperature profile is rapidly increased at noon (37.63°C highest). And from 3 pm the temperature starts to reduce rapidly. After 5 pm the temperature profile of the upper space remains lower than indoor living space temperature profile. With 25% window openings the upper space temperature is increased by convection and radiation process during day time and at night allows long wave radiation for cooling. Therefore, window openings of the upper space are a significant factor to be considered in this research. The upper space temperature was higher than the outdoor temperature at day time. The convectional heat gain by window and direct solar radiation heat gain by C.I sheet roof have influence the increase of the temperature of the upper space. Indoor space temperature reached its peak after three hours later than upper space maximum temperature. The upper space is transmitting heat into indoor space during day time which creates an uncomfortable indoor environment. From 9am to 3pm the upper space air temperature is rising and it remains higher than the outdoor temperature.

For the average minimum air temperature difference between indoor and outdoor was 7.34% of outdoor range. During day and night time average maximum air temperature difference was 6.08% of the outdoor range. The average air temperature difference between upper and indoor at day time was 14.36% and at night was 8.49% of indoor range. At night, the upper space temperature decreased immediately after sunset.

The significant findings, during 25% window openings in upper space, are suggested that, the upper space influence the increasing of the indoor temperature during day time. But it is helpful for night cooling process, by long wave radiation and convectional heat loss of upper space.

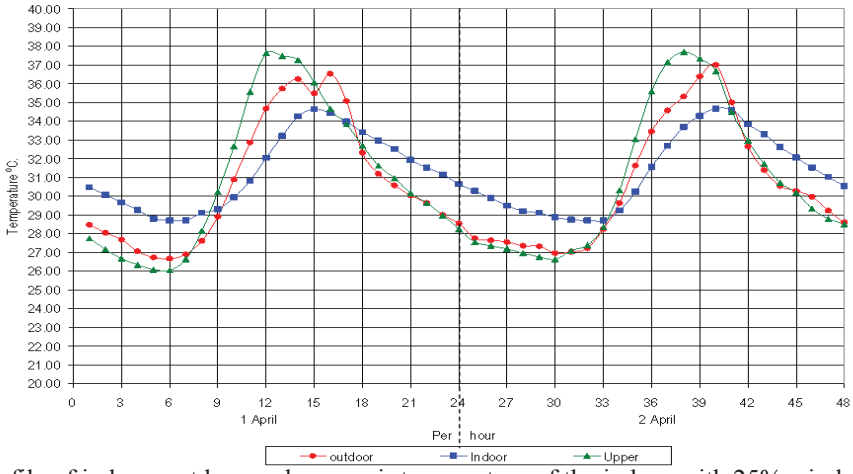


Figure 11: Profile of indoor, outdoor and upper air temperature of the indoor with 25% window opening in the upper space in summer season

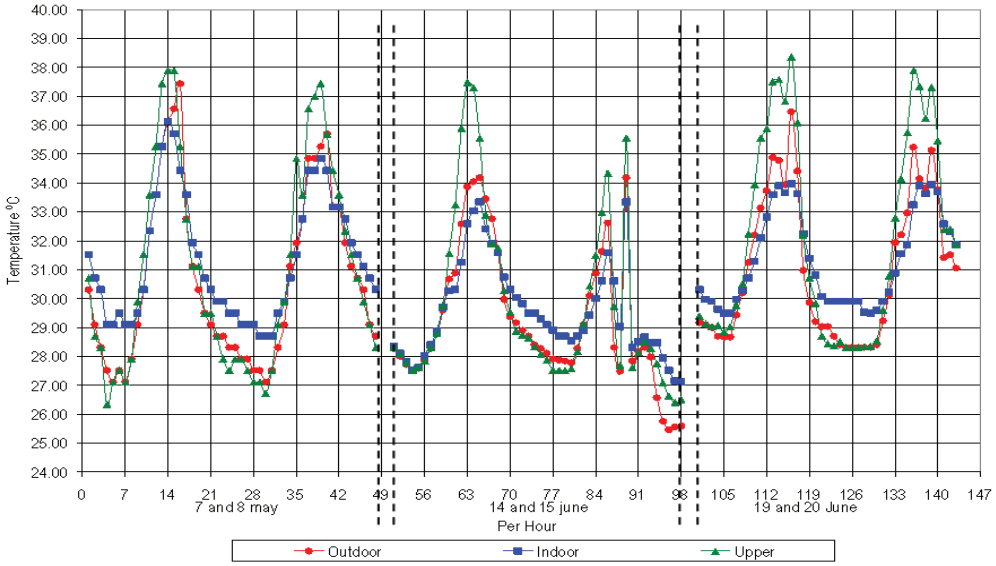


Figure 12: Profile of indoor, outdoor and upper air temperature of the test room with 75% window opening in the upper space in summer season.

With the increase of opening percentage of upper space 25% to 75% the indoor air temperature also becomes hotter than outdoor ambient environment. During summer night, with 25% and 75% openings, the relationship is Ti>Tu<To can be expected for most of the period at night when upper space radiant temperature is below than outdoor ambient air temperature. With 75% window openings in the upper space this creates more comfortable indoor environment compare to 25% opening of windows in the upper space. More openings allow more convectional heat loss with ambient air and long wave radiation cooling at night. So window opening of upper space plays a vital role to keep the indoor living space temperature within comfort temperature range (24°C to 34°C) during night.

Table 3: Daily Maximum and minimum temperature difference with different percentage of upper space window opening in winter and summer seasons

Season	Month	Window opening of upper space	Condition	Temp. diff. (To-Ti)/ To %	Relation Between Ti,& To	Relation Between Ti, Tu, & To
Winter	January 12th	0 % percent Himalayan wind cold flow	Day Max	2.46	Ti<To	Ti<Tu>To
			Night Min	3.67	Ti>To	Ti>Tu<To
	February 10th	0 % percent Commoncondition	Day Max	3.22	Ti<To	Ti<Tu<To
			Night Min	12.68	Ti>To	Ti>Tu>To

Summer	March 8th	0 % percent	Day Max	10.46	Ti<To	Ti<Tu<To
			Night Min	17.60	Ti>To	Ti>Tu>To
	April 2nd	25 % percent	Day Max	4.56	Ti<To	Ti<Tu>To
			Night Min	7.08	Ti>To	Ti>Tu<To
	May 7th	75 % percent	Day Max	2.38	Ti>To	Ti<Tu>To
			Night Min	5.74	Ti<To	Ti>Tu<To
	June 19th	75 % percent	Day Max	6.83	Ti<To	Ti<Tu>To
			Night Min	2.90	Ti>To	Ti>Tu>To

From the table 3 it is summarized that when upper space window opening's percentage increases than indoor and outdoor temperature difference decreases during summer day time. But the upper space temperature chronologically becomes higher in respect of percentage increasing of upper space window opening. The difference between indoor and outdoor temperature decrease because of heat starts to transmit from hot upper spaces to cool indoor living spaces. According to this phenomenon from the tabulation, it is indicated that it has sufficient difference between indoor and outdoor temperatures during summer nights. So the upper space influences the indoor living space for heat gain and heat loss. Finally, it is suggested for better performance of the traditional house in Bangladesh during summer seasons, the window of upper spaces should be closed before sunrise and should be opened as early as possible after sunset. During winter season closed window in upper space is desirable for better thermal performance.

7.4 Evaluation of Indoor Comfort Zone for winter and summer Seasons

Relationship between daily average indoor relative humidity and daily average indoor temperature of the indoor space with superimposing summer and winter comfort zone are shown in figures 13 & 14. According to winter comfort zone (Sharma and Ali, 1986; Mallick, 1994;) relation between indoor air temperature and relative humidity of the selected house with winter comfort zone of only 2% temperature points are out of the comfort zone and according to summer comfort zone (Mallick, 1994) only 9% temperature points are out

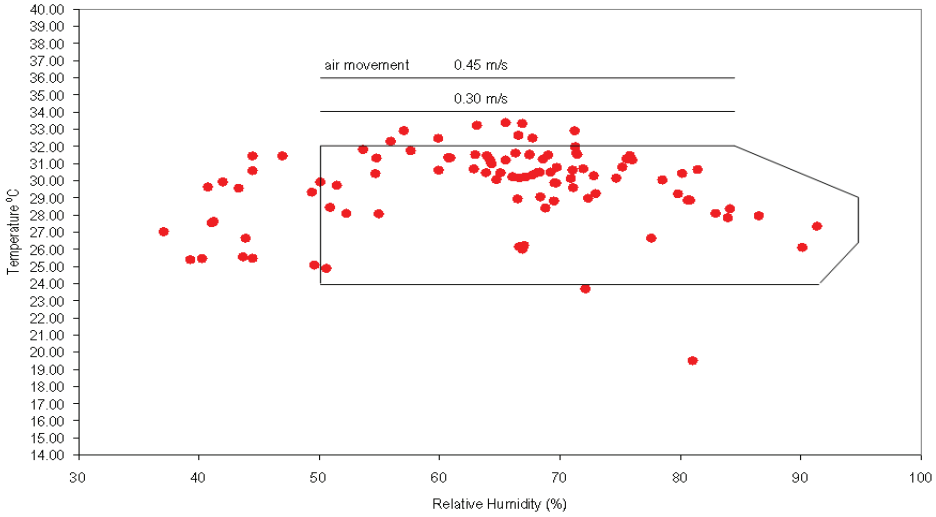


Figure 13: Plotting of the indoor temperature and relative humidity of the indoor within summer comfort zone.

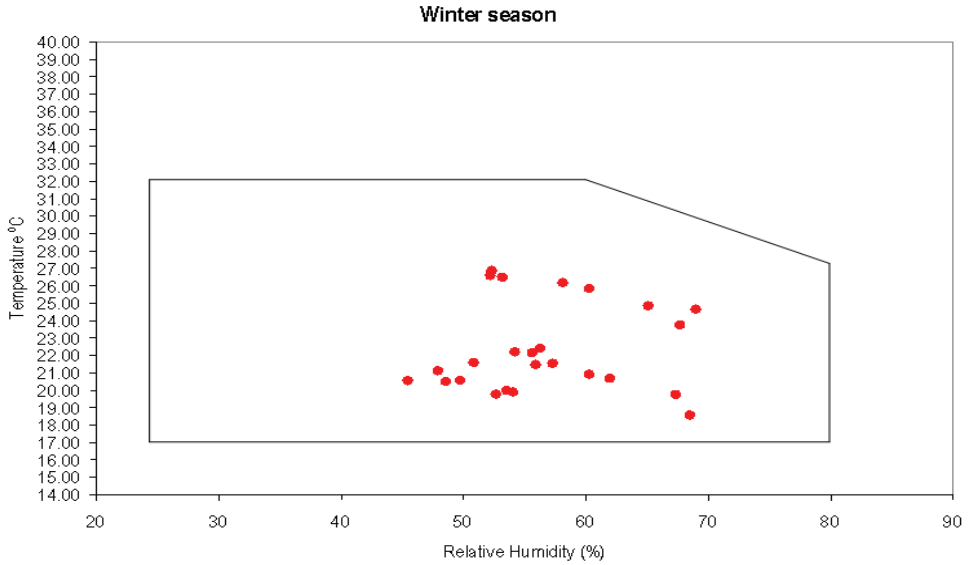


Figure 14: Plotting of the indoor temperature and relative humidity of the indoor within winter comfort zone.

of comfort zone. Whereas, the concentrate maximum of points are between 40% - 85% relative humidity and temperature are 25°C -34°C. From the figure 14, it is indicated that March month is dry and May is the hottest month according to this research. However, with the increase of air flow 0.3m/s, the comfortable condition of indoor living thermal environment can be achieved successfully in the traditional house in Bangladesh in the context of Dhaka city. The compactness of surroundings was affecting the traditional houses in Dhaka. So it is evident, that a more desirable environmental condition exists in the traditional house. By keeping the originality of the traditional house, it can

contribute to providing the natural thermal comfort for people although the house lies in the high density environment during both summer and winter season.

8. Conclusion

The research found that the Bangladesh traditional houses still have a better ability in providing the thermal comfort especially at a dense environment such as Dhaka city in Bangladesh. It is proved that the indoor living space environment is comfortable in both summer and winter seasons during night time. Research results further more indicate that to achieve better thermal performance in Bangladesh for traditional houses, during winter season, windows of upper space for both day and night time used to be closed. During the summer seasons, the window openings of upper space need to be kept closed as early as possible after sunrise and open after sunsets. The upper space of the traditional house in Bangladesh has a provision of operable windows which can perform as an efficient combined radiator and as a passive cooing means. So the upper space has a natural successful implementation of cooling concept. This study concludes that the use of upper spaces in Bangladesh traditional houses has a significant impact on the thermal performance and thus it makes the traditional house more efficient and sustainable in natural warm humid climate.

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السعة الحرارية في بيت بنغلادش التقليدي في بيئة كثيفه عاليه مع الشرط المحيط الأسوأ في مدينه دكا

دراسة حالة البيت التقليدي البنغلاديشي في جولشان في مدينه دكا

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الملخص:

البيت البنغلاديشي التقليدي هو مثال السكن النموذجي الذي يشكل القيم الثقافيه الاجتماعيه للبلاد والشكل التقليدي. البيـوت البنجلاديشيـه التقليديـه كانت ممثل جيد من البيـوت الإستوائيه الرطبه الدافئة التي تستطيـع التكيف بشكل جيد للمنـاخ المحلـي ويتعاون بشكل جيـد مع الاعتقاد والتقليد المحلـي بالإضافه الى المواد المحلية. الشـرط المحيط الأسوأ الكثيف للغايـه مـن مدينه دكا له تأثير الى نوعيـة المناخ الداخلي والخارجي، يؤثـر الى السعة الحرارية في البيـت التقليدي. السؤال هـو كيف أن البيـت البنغلاديشي التقليدي يستطيع أن يساهـم في تزويد السعة الحرارية في البيئـة الكثيفة. الطريقة الكمية تستخـدم لقياس الأداءات الحراريه. الدراسة الميدانية أجريـت بإستخدام مسجلات البيانات الحراريه. مجموعة مسجلات البيانات الحراريه ركبت في بيوت بنغلاديش التقليديه المختارة في مدينة دكا لتسجيل درجة حرارة الجو الداخلي والخارجي والأماكـن العلـي. جمع البيانات نفذت لمـدة شهرين في الشتاء واربعه شهور في الصيف. نتيجـة البحث كانت من الواضح بأن البيـت البنغلاديشي التقليدي مـا زال في الأصل لديه القدرة الأفضل في تزويد السعة الحرارية خصوصا في البيئة الكثيفة في مدينة دكا في بنغلاديش. ان استخدام المكان (الفراغ) الأعلى في بيت بنغلاديش التقليدي له تأثير هام على السعة الحرارية الداخليـه العامـه. أثبت (برهـن) على شرط درجة حـرارة الجو الداخلي الـذي يستطيع ان يصنف بمنطقـة السعة. هكذا وبالتالي، البيوت الحديثة يجب أن تعتبر توظيف هذا المكان الأعلى لإنجاز السعة الحرارية.