

**THERMAL PERFORMANCE OF BANGLADESH
TRADITIONAL HOUSE
DURING WINTER AND SUMMER SEASONS**

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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. Currently, urban development in Bangladesh is threatening the traditional houses. Study on performance of traditional houses in Bangladesh is also rare compared to researches done on the contemporary or modern houses. Thus, the aim of this study is to evaluate the thermal performance of Bangladesh traditional houses in the context of Dhaka during summer and winter seasons. 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 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 found that the traditional Bangladesh house is comfortable in both summer and winter seasons. It also noted that the thermal performance of traditional house depended on the different percentage of window openings in the upper space during both seasons. During the winter time as expected, closing the window openings throughout the day provided good thermal indoor environment. However, during summer seasons, closing the window openings of the upper space in the day time and opening them at night resulted in better thermal comfort indoor. This finding is important as it is contrary to the conventional belief of the occupants that opening their windows in the upper spaces during daytime in the summer will provide cooler indoor temperature. This study concludes that the use of upper spaces in Bangladesh traditional houses have significant impact on the overall indoor thermal performance. Thus, modern houses should consider employing this upper space to achieve thermal comfort.

ABSTRAK

Rumah tradisional Bangladesh merupakan contoh kediaman yang tipikal dimana ia mengambil kira nilai budaya negara dan bentuk tradisionalnya. Pada masa ini, pembangunan bandar di Bangladesh telah mengancam rumah tradisional. Kajian tentang prestasi rumah tradisional pula adalah amat kurang jika dibandingkan dengan kajian ke atas rumah moden atau kontemporari. Oleh itu, kajian ini bertujuan untuk menilai prestasi terma rumah tradisional dalam konteks Dhaka semasa musim panas dan dingin menggunakan metod kuantitatif. Kerja lapangan dijalankan menggunakan pengumpul data terma. Satu set pengumpul data terma digunakan bagi pengukuran dalaman dan luaran rumah serta dalam ruang atas atau juga dipanggil loteng. Pengumpulan data dibuat selama dua bulan dalam musim dingin dan empat bulan dalam musim panas. Kajian ini mendapati rumah tradisional Bangladesh ini adalah selesa bagi kedua-dua musim panas dan dingin. Kajian juga mendapati prestasi terma rumah tradisional ini bergantung kepada perbezaan peratusan bukaan tingkap di loteng untuk kedua-dua musim. Seperti dijangkakan, menutup tingkap sepanjang hari dalam musim dingin menghasilkan lingkungan terma dalaman yang lebih baik. Sebaliknya, sewaktu musim panas, menutup bukaan tingkap pada siang hari dan membukanya pada waktu malam memberikan keselesaan terma dalaman yang baik. Dapatan ini adalah penting kerana ia adalah berlainan dengan kepercayaan biasa pengguna yang beranggapan membuka tingkap di ruang atas atau loteng pada waktu siang akan memberikan suhu dalaman yang lebih sejuk. Kajian ini menyimpulkan bahawa kegunaan loteng memberikan kesan yang jelas terhadap prestasi terma dalaman secara keseluruhan. Oleh itu, rumah moden perlu mengambil kira penggunaan loteng ini untuk mencapai keselesaan terma dalaman.

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

Traditional House represents the heritage of Bangladesh and also reflects traditional forms and values, fundamental to the culture of the people 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. For centuries traditional houses has been using locally available materials. It is only from the late 19th century that the traditional houses began to change in the use of materials. Traditional architecture in Bangladesh was largely built without formally trained professionals. Buildings were built by construction workers. The full planning concept has been developed by the people according to needs. The traditional house has been changed along with time to fulfill the demand of the user. At the same time planning concept remains constant. The different kinds of houses were developed in different climatic regions of Bangladesh such as mud houses, bamboo houses, stilts houses and timber houses. The stilts house was selected for this research study. The reason will be discussed at the end of this chapter.

Dhaka, being the capital of Bangladesh is the most important city of the country. In addition to housing the central administrative and institutional facilities, the city now accommodates nearly 6 million people (Population Census 2006) on an

area of 815 square kilometers. The above two figures indicate density of about 8251 persons per square kilometer. A considerable portion of land of the city is now under the control of law-enforcing authorities and that in fact results in higher densities in habitable area. According to Climatologists, the growth of high-rise buildings at close proximity and the use of vehicles have changed the general city climate and have created numerous micro-climates in some areas. It is obvious that such changed microclimates can affect the climates inside the adjacent traditional house.



Figure 1.1 Dense Dhaka city skylines during day and clouded night (lower left) and traditional stilts house (lower right).

The roof is the main element of the house that has much exposure to the sun and therefore gains solar radiation. 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 (24°C to 32°C by Mallick, 1993) in summer seasons (Abul Mukim Mridha, 2002). Mechanical cooling is a very expensive (per unit 3.5 taka) option. In such a context, developing passive means of the solar control is important for comfortable living and higher productivity during hot seasons of the year. Traditional houses are designed by the owners according to demands and are based on low investment, rebuildable structure and use of local materials. In Bangladesh modern house, reinforced concrete roof is very common but uncomfortable for living at night (Abul Mukim, 2002). Mechanical cooling is a very expensive option.

In terms of energy used, the distribution of the critical hours has considerable importance particularly during the summer months when the consumption of energy (electricity) is expected to increase. The hours between 10am and 5pm the energy consumption is at its peak (figure 1.2; Sabbir Ahmed 1995).

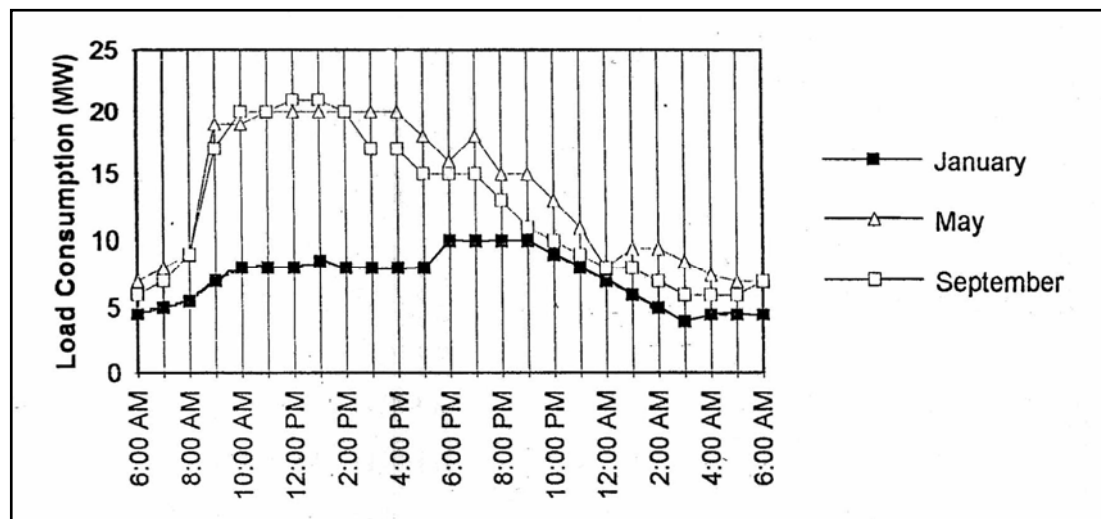


Figure 1.2 Variation in energy consumption at different time of the year in Dhaka city.

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 indoor space. This is the main issue that influences this research.

1.2 Statement of the Problem

In Bangladesh the temperature difference between rural and urban area is 4°C to 5°C (Mallick, 1993) because of the amount of hard surface along with the high outdoor temperature. Traditional houses are based on low investment and high maintenance and the general construction materials are mud, bamboo, thatch wood C.I. sheets etc. These houses are extensively protected from effects of solar radiation by trees, open surroundings allowing easy cross ventilation, which produce its own microclimate, often include good solution of climatic comfort problems. For technological limitations and the always-overriding considerations of safety, some of these solutions must be considered ingenious (Koenigsberger et al, 1973). But in cities due to heavy concentration of the surrounding built environment this is not always successfully achieved. Most of the activities are performed outdoors. So indoor comfort is mainly important during night time (Mallick, 1993).

1.3 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.

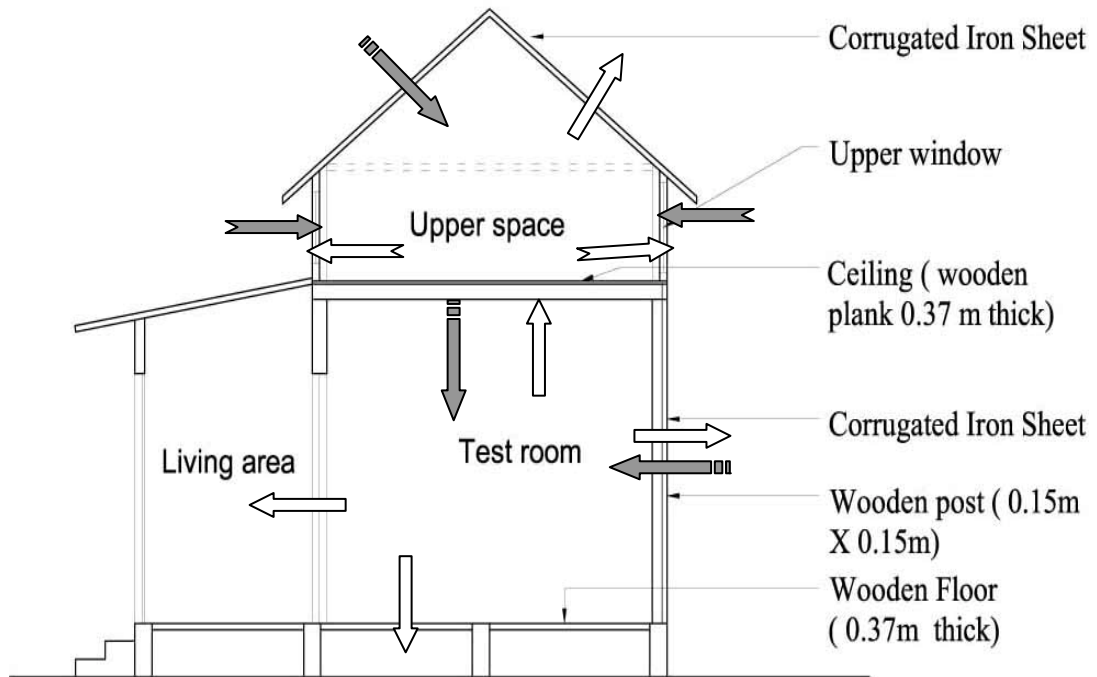


Figure 1.3 Cross-section of the test house

The window openings of the upper space play a vital role for the thermal environment of the traditional house.

1.4 Research Questions

The following questions will be addressed in this thesis:

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?

1.5 Research Gap

Very few studies were done about thermal performance and thermal comfort in respect to Dhaka city. The thermal performance of the operable roof insulation with special reference to Dhaka done by Abul Mukim Muzzammel Haque Mridha, (2002). He recommended that operable roof insulation at 450mm and 300mm height above the roof confirms that roof insulation at relatively higher height performance better than lower height. The factors for thermal comfort in residential high rise in Dhaka city is done by Bijon Behari Sarma, (2002) and suggested that the roof of the top floor be rendered heat-registrant by using suitable means.

There is no specific research done to study the thermal performance of upper space of traditional house in Bangladesh. Most of the research's are on the contemporary architecture in Bangladesh.

Previously some attempts were made to improve roof insulation. A study by Imamuddin et al (1993) and others using hollow blocks plastered over concrete roof has found differences of about 4-5°C between the ceiling surfaces of such an insulated slab as compared to a standard concrete slab for flat roofs. The difference was more for inclined roofs. The difference in room temperature was however less, a maximum of 2 °C. But the study is incomplete, as it did not record temperature data for 24 hours.

Another study was conducted by F.H. Mallick (1993) by using earthen pots laid over concrete roof. The room temperature of insulated roof was found to be 2.5-3.4°C lower in comparison without insulated roof at around 3pm.

It is evident from both experiments that using fixed insulation on the roof top, day time temperature can be reduced to a lower level but these methods reduce the potential of radiant cooling as in both cases the indoor temperature is higher than the outdoor.

These studies suggest suitable means or insulation for modern building roofs. However, the traditional house with double layer roof sections (upper space),

appears to have solved the thermal environment of the traditional house. Therefore, this thesis attempts to focus on the thermal performance of the roof section in traditional house with different window openings in respect to the impact of indoor temperature during different seasons in Dhaka city.

1.6 Research Objective

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 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 difference percentage of window openings and how they influence the indoor thermal environment.

1.7 Scope and Limitations

1. The scope of research is to investigate the thermal performance of the traditional roof section and the changes that occurs in the indoor thermal environment with diurnal variation of the room during summer and winter season.
2. The main limitation was during the field investigation from 10th January to 20th June. Some degree of uncertainty was present in the data collection by thermal data Logger such as -69°C to 289°C from 27th January to 8th February and 11th February to 25th February. For this reason, the above mentioned period data was not analyzed in this research.

3. The following days were chosen for hourly analysis

Season	Month	Selected Dates
Winter	January	12, 13, 18 ,19 20 & 21
	February	10, 11, 27 & 28
Summer	March	7 & 8
	April	1 & 2
	May	7 & 8
	June	14, 15,19 & 20

4. They were only short winter periods (December to February) and there was delay in (9th Jan) getting the equipment from the supplier to start the field measurement. The thermal data logger also recorded some degree of uncertainty during the winter period. For these reasons, this research did not manage to analyze the thermal performance of the traditional house with different percentage of wall openings in the upper space.
5. Due to the limitations of the thermal data logger, the field measurements and data collection were possible only in one house (test house).
6. Wind flow also can have an effect on thermal performances of house but it is not considered in this experiment because of field study site is a highly dense area at Gulshan. Highest wind speed occurs in April 2.9 m/s and lowest in November 1.3 m/s. Because of the surroundings, effective cross ventilation was not achievable in the test house. There are other parameters effecting the thermal comfort, for e.g. air velocity, clothing, sky conditions and metabolic heat production, which are not considered within this research work
7. The thermal comfort aspect was mainly dealt based on indoor to outdoor temperature differences.
8. Above these opportunities and constraints, research on the thermal performance of the upper space in Bangladesh traditional house with

reference to dense Dhaka city was carried out and described in the following chapters.

1.8 Significance of the Research

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 further 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 designers. 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.

1.9 Research Position

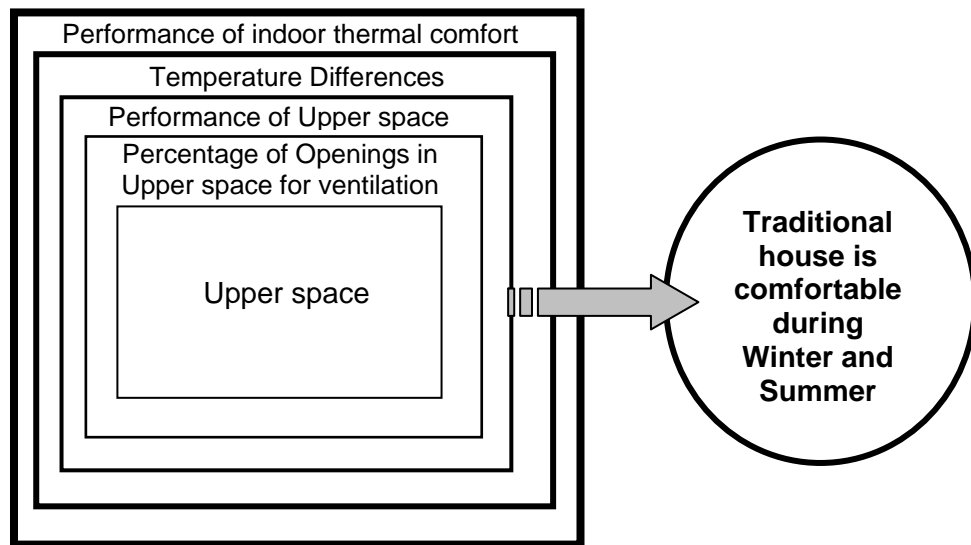


Figure 1.4 Diagram of research position.

1.10 Thesis Structure

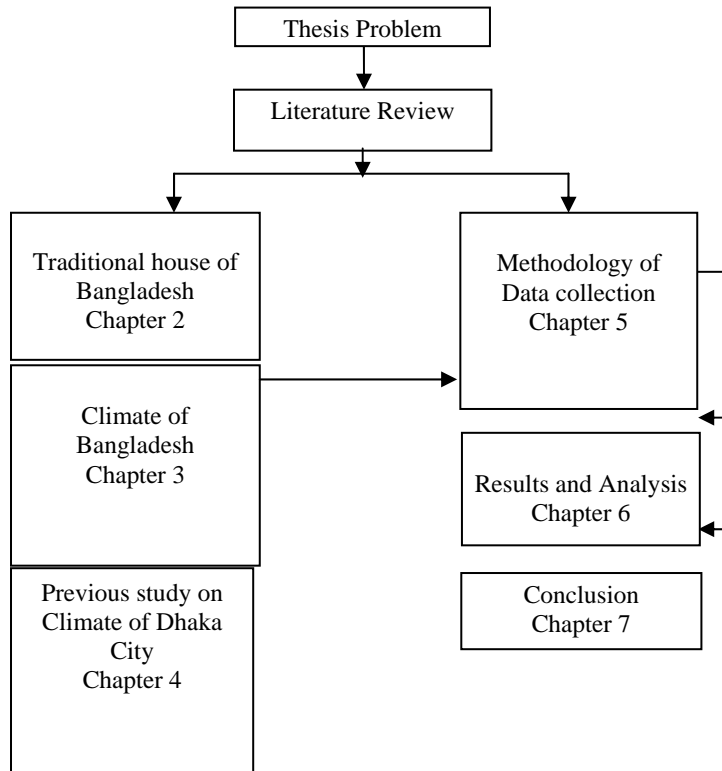


Figure 1.5 The flow of research process and thesis structure.

The thesis is organized into seven chapters as summarized below.

Chapter one introduces the main issue of this research. This chapter also introduces the statement of the problem, objectives of the study, scope and limitation of the study and significance of the research. The research gap, research questions and research hypothesis and the overall thesis structure are also presented in this chapter.

Chapter two introduces the typology of the traditional houses of Bangladesh. This chapter describes the various types of the traditional houses of Bangladesh according to materials used, history and transformation of the traditional houses. The upper space (Attic) is also discussed in detail.

Chapter three presents the classification of climate and climatic region of Bangladesh. This chapter vastly explains the urban climatic elements of Dhaka city such as temperature, rain fall, humidity, wind speed etc.

Chapter four introduces the historical background of the Dhaka City. The previous study of climate, climatic comfort, indoor comfort, summer comfort zone, outdoor comfort, summer comfort zone will also be explained. Environmental criteria and comfort vote are also described in this chapter.

Chapter five introduces the methodology of this research. It describes the objective of the methodology and description of the selected traditional house in Dhaka city. Instrumentation, installation of thermal data logger (Hobo) and placement of logger and methodology of data collection are also mentioned here.

Chapter six presents the results and analysis of this research. It describes the temperature difference of outdoor, indoor and upper space with the change of seasons and also with different percentage of window openings of the upper space. Temperature difference between Bangladesh Meteorological Department and field study data are also explained here.

Chapter seven presents the overall review of the thesis objectives and research questions, followed by the concluding remarks of the major findings of the experiment. Finally, it suggests further works to complement the thesis findings.

1.11 Conclusion

What has been discussed in this chapter is a brief introduction of the subjects that might be necessary for the understanding of this research. It included, a brief about the hypothesis and objective of the study, background information on Bangladesh and Dhaka city, the context regarding traditional houses of Bangladesh in Dhaka city and past investigations on thermal comfort etc. Finally a brief discussion on the research structure for this study has also been included in this chapter.

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