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IMPACT OF DIFFERENT WINDOW TYPES IN REGULATING NATURAL VENTILATION OF RESIDENTIAL BUILDINGS OF DHAKA, BANGLADESH

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ABSTRACT

Natural ventilation is most desirable for cooling and providing fresh air in residential buildings for better indoor air quality and thermal comfort. The natural ventilation performance is affected by a combination of internal and external factors. External factors include the location, the orientation, the prevailing wind speeds and the building forms of the residential development, which are subject to constraints beyond the control of site planners and architects. Whilst for internal factors like the openings configurations and window types, site planners and architects are always given free hand for a proper design. Dhaka, a city in the Tropics, has become such a city where with rapid urbanization users are moving towards mechanically ventilated buildings putting ever increasing demand on the dwindling energy resources. This paper focuses on the influences of window types on the natural ventilation of residential units in Dhaka in order to improve quality of indoor living environment. Primary objective of the study is an attempt to investigate the performance of different types of windows which is commonly used in residential buildings of Dhaka city. It is expected that the findings will immensely help design professionals practicing all climatic contexts where ventilation is an important design consideration.

KEYWORDS: Dhaka City and Tropics, Performance Evaluation, Residential Building, Simulation Study, Window Types

INTRODUCTION

The concept of sustainability in building and construction has evolved over many years. In fact, the United Nations Centre for Human Settlements acknowledges that housing is now universally recognized as a human right and that effort to implement this right must be strengthened and accelerated. Furthermore, the success and progress of human society depends on physical infrastructure, and a nation's economic strength is reflected in its infrastructure assets. With almost 60 percent of world population expected to be living in urban areas by the year 2030, massive construction activity is taking place globally. Sustainable construction is a way for the building industry to move towards achieving sustainable development, taking into account the environmental, socio-economic and cultural issues. Specifically, it involves issues such as design and management of buildings, materials and building performance, energy and resource consumption - within the larger orbit of urban development and management. (S. Shams, K. Mahmud, and M. Al-Amin, 2011)

In Bangladesh, the demand of residential building is increasing high for it's over growing population. Therefore, a tremendous problem of energy crisis is seen to be created and subsequently demand of extra energy is increased for residential building to fulfill the demand of over population.

The local climate dictates that for indoor comfort, shading from solar radiation and cross ventilation through openings are required for having comfort in the buildings of warm-humid Bangladesh. Rapid rise in population in the capital city Dhaka, termed as a mega-city, has resulted in construction of high density apartment buildings all over Dhaka. Many of these, mostly six stories high, are compact buildings devoid of the traditional environmental element, and thus have dark interiors and poor ventilation.

This study focused on the investigation and evaluation of influences of different window types on the natural ventilation performance of typical residential buildings of Dhaka with the following objectives:

- To evaluate the influence of existing window types as climatic tool used in residential buildings of Dhaka based on the results achieved by the study.
- The identification of a better performed window type among this commonly used windows in residential buildings of Dhaka:
    - By investigating the pattern of **Daylight level** of various types of windows in residential buildings of Dhaka.
    - By investigating the pattern of **Air Temperature** of various types of windows in residential buildings of Dhaka
    - By investigating the pattern of **Relative Humidity** of various types of windows in residential buildings of Dhaka

Possible Outcome

Purpose of this study is to enhance the effective use of natural ventilation by using proper window type in residential buildings of Dhaka which can be used as evidence for standard architectural solution.

METHODOLOGY

In order to minimize energy crisis problem numerous researches have been carried in the last few decades. This paper presents the results of performance evaluation (based on natural ventilation) of a residential building with four different window configurations. The window configurations taken into considerations are; i) A typical window without shading; ii) A typical window with shading iii) A corner window with shading and iv) A corner window without shading. No various shading device and louvers are included in this analysis. Only one simple type of shading device is used for this study. The simple rooms having similar floor area, floor to ceiling height identical glazing (area and glass combination), glazing height and identical wall, floor and ceiling reflectance were taken into consideration in this study.

Some apartment buildings are selected for analysis in the present study. This building consists of 7 flats of different sizes in each floor and elongates in north-south directions. Bed rooms which are situated at the first floor in the south side of the building are taken into consideration in this study.

Table 1: Research Framework; Analytical Process is Conducted in these Following Steps

Step 01:	**Literature Review to Establish a Research Framework:** Step 01 was a review of the relevant literature and research work that had been done on various window types of residential buildings and its influence on natural ventilation. This forms the foundation of this study.
Step 02:	**Preliminary Observation for Sample Selection:** Selection of window types by fixing some investigation parameters.
Step 03:	**Setting Study Parameters:** Fixation of climatic parameters for analyzing the influence of window types on the natural ventilation performance, under varying outdoor and surrounding building conditions. The methods adopted for this study was explained and presented.
Step 04:	**Use of Instruments:** Selection of Study Area and identifying their indoor climate ie. Air temperature, relative humidity, daylight level of various types of windows using different instruments. Finalization of Questionnaire format to see the user response.
Step 05:	**Data Analysis and Synthesis:** To establish a correlation between different types of windows and their Influence on natural ventilation of residential buildings of Dhaka.
Step 06:	**Conclusion:** Provided the conclusions of this study.

Preliminary Observation for Sample Selection

Before making selection of window types, residential buildings are identified and surveyed. These residential buildings are located in different residential areas in the Dhaka city. After that, buildings were categorized considering the typology (based on geometry) of shading devices installed on their front façade. Sketches of window sections with shading device of these buildings were prepared with detail construction features, installation technique and geometric features. After analyzing the sketches, four window types were selected to evaluate performance in terms of natural ventilation considering shading device typology and similarities in geometric features. The wall of the whole building is considered to be constructed by local brick and the color of the inner sides of the wall is considered as white. Room height is considered as 3.00m and walls thickness is considered as 125mm. Ceiling is considered to be constructed by RCC with a thickness of 125mm.

Setting Study Parameters

To do the field study, a specific day has been selected (from the weather database for the year 2012) on the basis of some specific attributes to observe the results. The test day is 26th May 2012. Outdoor air temperature range of this day is 36.2 °c (Max) and 28.8 °c (Min) and outdoor relative humidity range of this day 74 % (At morning) & 61 % (At evening). The sky condition is clear. From 0900-1700 hours the cloud cover is 1.1 out of 8.0 (13.8% coverage). This is a day with considerable high outdoor air temperature but not the extreme one and bears a common character regarding the climatic features especially of the hot-dry season. The average temperature of this day (32.5ºC) is very close to the average temperature of the season. It has been observed that the sky condition in the given climate is clear for 67 percent of the whole pre-monsoon period and the 'clear sky' condition prevail for the chosen day.

Use of Instruments

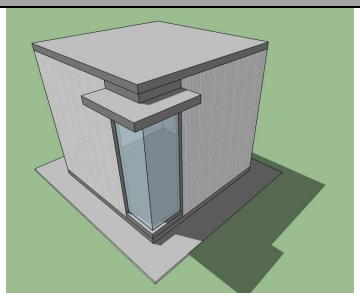
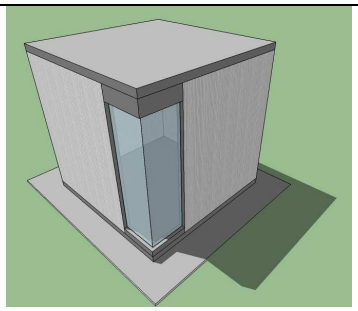
Identifying the indoor climate ie. Air temperature, Relative humidity, Daylight level etc. of various types of windows of bedrooms using different instruments. Problems and effects of natural ventilation were discussed with the users of various floors of the selected apartment.

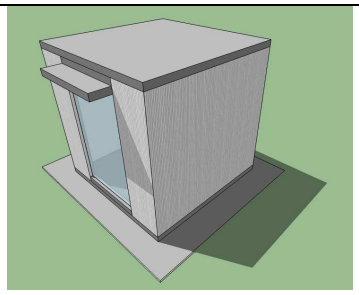
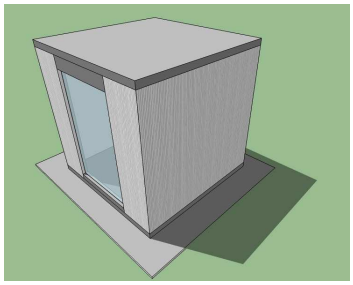
Table 2: Questionnaire Format

Environmental Variables	Measuring Tools for Environmental Data	Questions
Air Temperature	Digital Scientific Hygrometer	How does the air feel? Does the temperature vary with different time of the day? Does the temperature of the place change a lot with seasonal variation?
Humidity	Digital Scientific Hygrometer	Is the place affected by indoor plantation? Do you feel that the air is humid?
Air movement	Smoke and Ribbon, Glove (Mosquito Coils)	Do you feel the space airy? Which direction does the air come from?
Daylight	Light meter	Is the place sunny or shaded?

Digital hygrometer (Model No: KT 905) has been used for measuring indoor Air temperature and Relative humidity. Glove (Mosquito Coils) has been used for measuring indoor Air movement. Light meter 1330 B lux foot candle was used to measure workspace luminance level.

Table: 3 Case Studies for Field Study

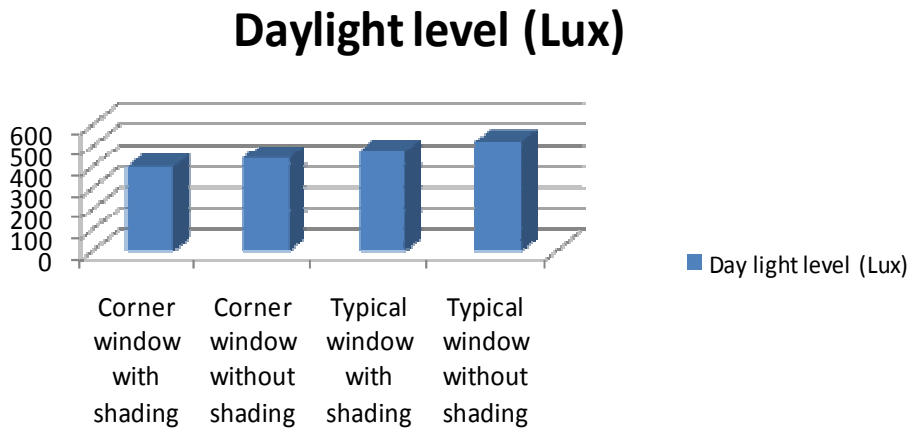
Isometric Representation	Case Study	Window Types
	Type 1	– A corner window with shading
	Type 2	– A corner window without shading

	Type 3	– A typical window with shading
	Type 4	– A typical window without shading

Data Analysis and Synthesis

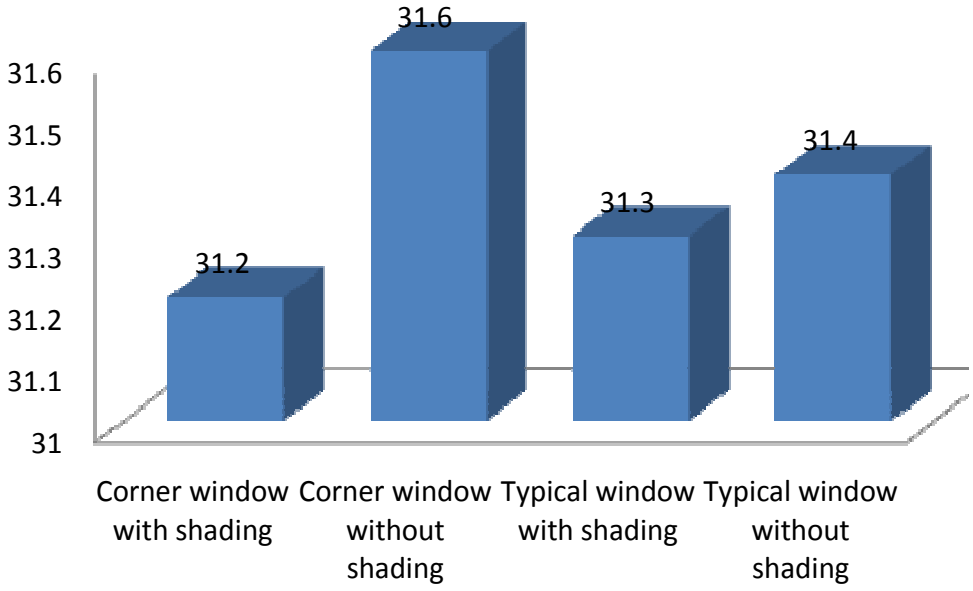
According to the field survey the daylight factor, room temperatures and humidity level were calculated with the help Digital hygrometer & Light meter for all types of windows.

To evaluate the shading performance on the basis of set criteria discussed earlier, a comparative analysis among the selected window types has been summarized in the following section.



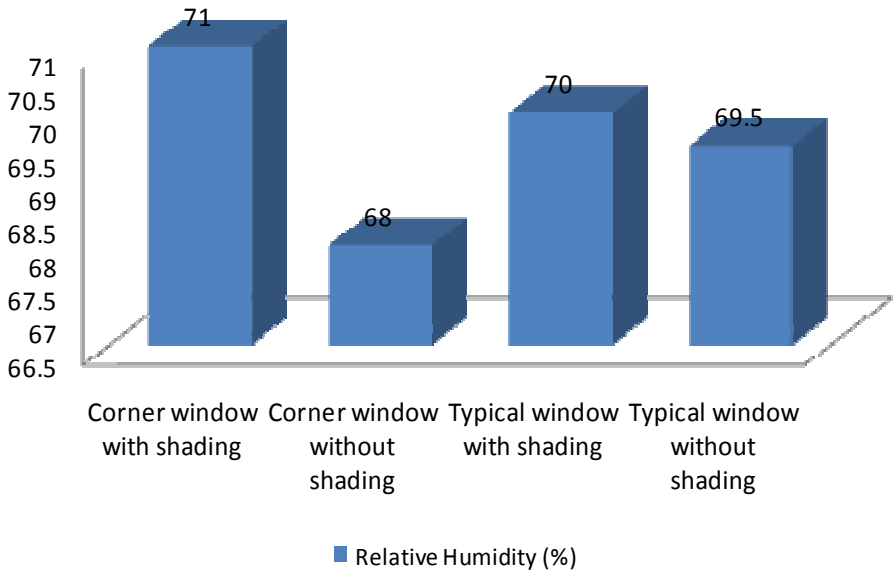
Graph 1: Comparison of Daylight Level of Various Type of Windows Pattern According to the Field Study

The penetration range of daylight in various windows according to the field survey is shown in Graph 1. From this graph it is seen that typical window without shading device has achieved the highest penetration range (the last corner image). It is seen that when day light is high in the inner side of the room, discomfort level is created and temperature becomes high. The change of temperature for four analysis cases is shown in Graph 2. It is seen that the use of shading device, indoor temperature reduces significantly.



Graph 2: Comparison of Indoor Temperature Level of Various Type of Windows Pattern

Thermal comfort level of various type of windows pattern is shown in Graph 2 In this figure it is seen that room temperature without shading in typical windows is always high for all patterns of windows. Among them corner window without shading is found to be the highest temperature.



Graph 3: Comparison of Indoor Relative Humidity Level of Various Type of Windows Pattern

Indoor Relative Humidity of various type of windows pattern is shown in Graph 3. In this Graph it is seen that Relative Humidity with shading windows either typical or corner is always high for all patterns of windows. Among them corner window with shading is found to be the highest Relative Humidity. Corner pattern window without shading shows discomfort able range of Relative Humidity.

Following chart have been made on the findings of present study (Questionnaire Survey). From the analysis of 68 persons Questionnaire survey report is showing that 16 samples who are living in a room having corner window without shading device for all floors have no comfort problem and other's have shown various opinion because of different orientation of windows as shown in Table 04.

Table 4: Result from Questionnaire Survey

Study Area	Comfort Range (%)
A room having typical window without shading device for all floors.	Uncomfortable : 88% (15 among 17 samples) Comfortable :12% (2 among 17 samples)
A room having typical window with shading device for all floors.	Uncomfortable : 18% (3 among 17 samples) Comfortable : 82% (14 among 17 samples)
A room having corner window without shading device for all floors.	Uncomfortable: 0% (0 among 16 samples) Comfortable : 100% (16 among 16 samples)
A room having corner window with shading device for all floors.	Uncomfortable : 33% (6 among 18 samples) Comfortable : 67% (12 among 18 samples)

DISCUSSION

The investigation was carried out to understand the impact of window types on natural ventilation of residential buildings and to evaluate the performance of commonly used windows and shading devices in controlling natural ventilation. Analysis of the field study results indicated a clear understanding of the different window types and their contribution to the energy consumption & natural ventilation. From the comparison between options 'with' and 'without' shading device schemes, it has been shown that indoor climate of the buildings can be controlled by shading devices and it offers an opportunity to reduce energy requirement significantly.

Uncomfortable range of Air temperature: More than 30°c and less than 20°c are considered as uncomfortable range of air temperature as marked in Bio climatic chart.

Uncomfortable range of Relative Humidity: More than 65% and less than 18% are considered as uncomfortable range of relative Humidity as marked in Bio climatic chart.

By collecting and analyzing weather data (year 2012) from the Metrological Department of Dhaka, Bangladesh, and on the basis of bio climatic chart the following charts are prepared to analyze the survey results:

Table 5: Comparative Analysis of Air Temperature and Relative Humidity at Different Types of Windows

Types of Windows	Indoor Temperature as Recorded by the Researcher	Outdoor Temperature as Recorded by Metrological Dept	Indoor Relative Humidity as Recorded by the Researcher	Difference between Relative Humidity %(Recorded by Metrological Dept)	Difference between Temperature °C (Recorded by Metrological Dept & Recorded by the Researcher)	Difference between Relative Humidity %(Recorded by Metrological Dept & Recorded by the Researcher)
Type 01	**31.2**	36.2 °c (Max) 28.8 °c (Min)	**71**	**74 %** (At morning) **61 %** (At evening)	**Average Temp is 32.5°c** (according to metrological dept) **1.3 °c is less**	**Average Humidity is 67.5%** (according to metrological dept) **3.5 % is higher**
Type 02	**31.6**	36.2 °c (Max) 28.8 °c (Min)	**68**	**74 %** (At morning) **61 %** (At evening)	**Average Temp is 32.5°c** (according to metrological dept) **0.9 °c is less**	**Average Humidity is 67.5%** (according to metrological dept) **0.5 % is higher**
Type 03	**31.3**	36.2 °c (Max) 28.8 °c (Min)	**70**	**74 %** (At morning) **61 %** (At evening)	**Average Temp is 32.5°c** (according to metrological dept) **1.2 °c is less**	**Average Humidity is 67.5%** (according to metrological dept)**2.5 % is higher**
Type 04	**31.4**	36.2 °c (Max) 28.8 °c (Min)	**69.5**	**74 %** (At morning) **61 %** (At evening)	**Average Temp is 32.5°c** (according to metrological dept) **1.1 °c is less**	**Average Humidity is 67.5%** (according to metrological dept) **2.0 % is higher**

According to the Table 6, **Window Type 01** shows the highest difference in air temperature as well as in relative humidity from outside to inside. So this window type can moderate indoor ventilation positively than any other window types.

CONCLUSIONS

This study focused on evaluating the influences of window types on the ventilation performance of residential units in Dhaka. Field survey was carried out in a case study residential unit with different types of windows. Different instruments were used to simulate the natural ventilation performance for the use of different window types commonly adopted in residential buildings in Dhaka, which are corner window with shading, corner window without shading, typical window with shading, and typical window without shading. By data collection, the following conclusions were drawn:

- Corner window with shading (Type 01) performs better in admitting natural ventilation.
- In all cases windows with shading device has shown good performance than any kind of windows without shading device. Type 03 has shown better performance than Type 04.
- Corner window without shading (Type 02) is the worst in natural ventilation effectiveness.

- According to the questionnaire survey result discomfort has not been observed in a room having corner window without shading device for all floors because of its South-East position .From the survey result it is also clear that lower comfort level is observed in a room having typical window without shading device for all floors because of building orientation.

The conclusions can provide useful information for building designers to make a residential building be more natural ventilated, and hence energy conservation and comfortable. However, the conclusions were obtained by investigations based on weather conditions of Dhaka, they are effective just in those area of similar climate as Dhaka.

REFERENCES

1. Habitat (United Nations Centre for Human Settlements). (2001).Cities in a Globalizing World: Global Report on Human Settlements. London: Earthscan.
2. Hudson, R.W., Haas, R. and Uddin,W. (1997). Infrastructure management: design, construction, maintenance rehabilitation, renovation , McGraw-Hill, New York.
3. Syal, M., Hastak, M., Mullens, M. and Sweany, A. (2006). United States-India collaborative research directions in urban housing and supporting infrastructure, Journal of Architecture Engineering, Vol. 12, No. 44, pp.163-173.
4. Ding, G.K.C. (2008). Sustainable construction- The role of environmental assessment tools, Journal of Environmental Management, Vol. 86, No. 3, pp.451-464.
5. Afroz .J. Mahbuba & Tariq .H. Saiful . (2012). Effect of Fixed Horizontal Shading Devices in South Facing Residential Buildings at Dhaka, Bangladesh .Proceedings of the Global Engineering, Science and Technology Conference 2012, 28-29 December 2012, Dhaka, Bangladesh.
6. Ahmed .S. Khandaker, Haq Atiqul, Moniruzzaman Muhammad. (2006).Potentials of Window Design in Inducing Air change in Still Air Condition. The 23rdConference on Passive and Low Energy Architecture, Geneva, Switzerland.
7. S. Shams, K. Mahmud, and M. Al-Amin. (2011). Building Greener Homes Based on Coding and Rating System. IACSIT International Journal of Engineering and Technology, Vol. 3, No. 5.
8. Chowdhury. Sajal , Alam, Md. Rabiul, and Paul . Shajib. Daylight performance and energy consumption in a simple Room of residential building in Dhaka city, Bangladesh. Department of Architecture, CUET, Chittagong, Bangladesh
9. Rahman. Anisur , Ahmed .S. Khandaker, Protibesh .(2008).Observations on Performance of Commonly Used Shading Devices in Tall Office Buildings of Dhaka. Protibesh, BUET. Volume 12 Issue 2 pp. 15-26.
10. Ali.F. Zainab.(2007) . Comfort with courtyards in Dhaka Apartments. Department of Architecture, BRAC University Journal, Vol. IV, No. 2, pp. 1-6 .
11. GAO, Cai Feng and LEE, Wai Ling (2010). Influence of Window Types on Natural Ventilation of Residential Buildings in Hong Kong. International High Performance Buildings Conference at Purdue, Paper 16.

12. GAO, Cai Feng. (2011). The study of Natural Ventilation in Residential Buildings. A thesis submitted for the degree of Doctor of Philosophy, The Hong Kong polytechnic University.
13. Kavara P., Stathopoulos T. and Athienitis A. K. (2004).Wind driven flow through openings- a review of discharge coefficients. International Journal of Ventilation 3 (3):255-266.
14. Li Y., Delsante A. and Symons J. (2000).Prediction of natural ventilation in buildings with large openings. Building and Environment 35 (3):191-206.
15. Roetzel A., Tsangrassoulis A., Dietrich U. and Busching S. (2010). A review of occupant control on natural ventilation. Renewable and sustainable Energy Reviews 14 (3):1001- 1013.
16. FoE (2001).Indoor air quality (IAQ) survey. Friends of the earth, Hong Kong.
17. International Recommendations for Construction Statistics(1997), Statistical Papers, Series M, No. 47, Rev. 1, United Nations, New York. para: 73
18. Bulletin of Housing and Building Statistics for Europe and North America(2000), UNECE, Geneva. Annex II, Definitions and General Terms, page 83.