Performance of south facing windows for indoor ventilation & thermal comfort at Dhaka

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ABSTRACT

The way we think of Nature, thus ventilation, especially air flow greatly influences the form and substance of our daily lives, the buildings we design and therefore how they sustain the nature of place. Flow of air is one of the most important natural features available to architects to enhance the physical quality of interior spaces. Cross ventilation and wind flow is the major issue for thermal comfort of an interior space. Effect of ventilation is necessary for a residential building as it gives the users a comfortable and soothing environment. In residential buildings artificial ventilation is expensive to some extent. Maintaining natural air flow in the interior spaces is the only way for good health and healthy ventilation in a cost efficient way. In Bangladesh, it is preferred to provide openings at south because most of the time of the year southern wind flows over the country due to climatic situation. It is well known that a building having openings at south and at opposite or oblique corners is better ventilated. Placing the window is oblique (at 45°) to the inlet opening of the same room is the best solution for cross ventilation at Bangladesh. But a different scenario has been observed in south facing east-west elongated building. There are some openings which remains in wind shadow and failed to provide enough wind flow to the interior space although is placed in south facade. This paper focuses on discussing this factor affecting good ventilation, air flow and thermal comfort for the south facing opening position of a building. A horizontally elongated south facing residential building at Dhaka has been taken for the case study and analysis has been done on the basis of literature review, field survey and questionnaire survey.

Key words: Ventilation, thermal comfort, Wind pressure, windward & leeward side, window position.

INTRODUCTION

The way we think of Nature thus ventilation, especially air flow greatly influences the form and substance of our daily lives, the buildings we design and therefore how they sustain the nature of place. Flow of air is one of the most important natural features available to architects to enhance the physical quality of interior spaces. It is a resource in the tropics which the architects can use without any cost. In residential buildings artificial ventilation, that is, air condition is expensive in some extend. It is also not for good health to remain
under artificial ventilation even at home. So, maintaining natural air flow in the interior spaces is the only way for good health and health ventilation. Bangladesh is a tropical country and most of the time of the year we get southern wind because of our geographic location on the world. It is a common solution for the buildings of our country to provide windows facing south to receive the blessing of nature, southern wind and enough sunlight. It is well known that a building having openings at south and at opposite or oblique corners is better ventilated. But a different scenario is observed in south facing east-west elongated building. Air flow and ventilation differ for the south facing windows at different position of the façade. Therefore, placing windows at south is not the only solution, the window position in a long façade is also important in design to receive the southern wind.

**RESEARCH OBJECTIVES**

In many cases it has been observed that the comfortable condition due to ventilation and air flow is not always same in all the living areas in the same building, especially an elongated building. The study intends to find the ventilation and thermal comfort situation of different indoor spaces having windows in different position of an east-west elongated south facing residential buildings in Dhaka city. The research also search the answer, whether all the south facing windows get positive wind pressure or not for good ventilation properties.

**METHODOLOGY**

To conduct the research, a literature review has been made on wind flow and ventilation properties. A south facing east-west elongated residential building having open spaces at south has been fundamentally selected for the study. As the direction of wind flow in Bangladesh changes due to season change and the wind flow is not constant all of the year, it is difficult to measure the wind speed in a short time span to conduct a specific research. A detail field survey has been conducted by questionnaire of the occupants. The basis of questionnaire is based on thermal comfort and ventilation condition of different spaces. Finally, different living spaces have been named into some study areas to analysis and summarize the findings of the research.

**CLIMATE OF BANGLADESH**

Bangladesh has a tropical monsoon climate characterized by seasonal variations in rainfall, high temperatures, and high humidity. Regional climatic differences in this flat country are minor. Three seasons are generally recognized: a hot, muggy summer from March to June; a hot, humid and rainy monsoon season from June to November; and a warm-hot, dry winter from December to February. In general, maximum summer temperatures range between 38°C. and 41°C. April is the hottest month in most parts of the country. January is the coolest (but still hot) month, when the average temperature for most of the country is 16-20°C during the day and around 10°C at night.
Winds are mostly from the north and northwest in the winter, blowing gently at one to three kilometers per hour in northern and central areas and three to six kilometers per hour near the coast. Because of its location just south of the foothills of the Himalayas, where monsoon winds turn west and northwest, the region of Sylhet in northeastern Bangladesh receives the greatest average precipitation. About 80% of Bangladesh’s rain falls during the monsoon season. The monsoons result from the contrasts between low and high air pressure areas that result from differential heating of land and water. The southwest monsoon, commence in June and usually last through September. Dividing against the Indian landmass, the monsoon flows in two branches, one of which strikes western India. The other travels up the Bay of Bengal and over eastern India and Bangladesh, crossing the plane to the north and northeast before being turned to the west and northwest by the foothills of the Himalayas.

LOCATION AND CLIMATE OF DHAKA

Dhaka is the capital of Bangladesh. It is located at 23°45’ N and 90°25’ E, with an average surface elevation of 9m. Its three sides bounded by river Buriganga in the south, Tongi Khal (canal) in the north and the Turag River in the west. Dhaka belongs to the south-central climatic zone of the country, which can be characterized as a transitional zone between extreme climatic conditions of the north and milder conditions of the south.

- Monthly maximum temperature recorded in summer was 35.4°C (April)
- Monthly minimum temperature was 11°C (January) in winter
- The mean air temperature in the monsoon is at 28°C while it drops down to 20°C in the winter.

Steady cloud cover, mostly during hot summer, impedes long wave terrestrial radiation in to the space and reduces the nocturnal cooling potential of the night sky as a thermal sink. The diurnal range of temperature change remains narrow. Wind speed is relatively high in
monsoon (max 4.1 m/sec in July) and the direction is predominantly from south and southeast. In winter wind direction becomes north and northwest. Mean average annual humidity is 77% (varies between 60% - 90%). The city has a significant amount of rainfall (above 190 mm/month in average) and 70.8% of the total yearly rainfall occurs in monsoon, (max 400 mm in July and minimum 7 mm in January).

LITERATURE REVIEW ON AIR FLOW AND VENTILATION

FUNCTION OF VENTILATION:

Ventilation serves three distinct functions.

- Maintains the quality of the air in the building above a certain minimum level by replacing indoor air vitiated in the process of living and occupancy, by fresh outdoor air.
- Provides thermal comfort by increasing the heat loss from the body and preventing discomfort due to moist skin, this may be termed thermal comfort ventilation.
- Keeps the structure of the building cool when the indoor temperature is above that out-of-door, and this may be termed as structural cooling ventilation.

AIR FLOW DUE TO WIND PRESSURE

When the wind is blowing against a building, the straight motion of the air is distributed and deflected around and above the building. The air pressure on the sides facing the wind is elevated above atmospheric pressure (pressure zone) and on the leeward sides it is reduced (suction zone). In this way pressure differences are created over the building. When wind blows perpendicularly on a rectangular building, the front wall is subject to pressure while the sides and rear are under suction. If the wind direction is oblique, the

![Fig-03: Effect of wind direction on a building. Source: (Koenigsberger et al, 1973)](image)

Two upwind sides are under pressure and the others under suction. The roof is subject to suction in all cases. Pressure is not uniformly distributed over the windward surfaces of the building but diminishes outwards from the center of the pressure zone. Variations in pressure over the wall subject to a perpendicular wind are small, but when the wind flow is oblique there is a sharp drop in pressure from the windward to the leeward corners. When the angle of incidence is about 45°, the pressure at downwind corners almost disappears and at smaller angles suction develops there. The pressure distribution on the windward walls can be utilized to induce cross-ventilation even in rooms with one external wall.
DESIGN FACTORS AFFECTING VENTILATION

The pattern of air flow in a room is affected by two factors.

- The pressure distribution around the building
- Inertia of moving air

When the windows are provided in the windward wall of a room, the indoor pressure rises to equal the high external pressure on the wall. If the windows are in leeward side, the indoor pressure falls to the level of lower external pressure.

When windows are opened in both the windward and leeward sides of the building, a flow of air induced through the building from the high to the low pressure regions.

![Fig-04: Air flow around a building. Source: (Koenigsberger et al, 1973)](image)

WINDOW ORIENTATION AND THE WIND DIRECTION

It is generally believed that to give optimum ventilation conditions the inlet windows should directly face the wind, any deviation from this direction reducing the indoor air speed. In some recent cases, it is found that better conditions can be achieved when the wind is oblique to the inlet windows, particularly when good ventilation conditions are required in the whole area of a room. In a room with two windows in opposite walls, where the inlet directly faces the external wind, the main air stream flows straight from inlet to outlet and apart from local turbulence at the corners of the outlet wall, the rest of the room is only slightly affected. Air flow is slight along the side walls, particularly so at the corners of the inlet window wall. When the wind is oblique (at 45°) to the inlet opening of the same room, most of the air volume takes up a turbulent, circling motion around the room, increasing the air flow along the side walls and in the corners.

On the other hand, if two windows are located in adjacent walls, better ventilation is obtained with the wind perpendicular to the inlet window than when it is oblique, following the inlet-outlet direction.
CASE STUDY: STUDY OF AN EAST-WEST ELONGATED SOUTH FACING RESIDENTIAL BUILDING

The study building is situated in Malibagh, one of the densely populated areas of Dhaka city. It is a government colony for Rajuk officers. As like as the other government colony in Dhaka city, this building is also east-west elongated and this is an important reason for choosing this case for the study. This building is constructed on 1962-1964 and the area of per floor is around 3000 square feet. 3rd floor is selected for the study of wind flow to get optimum result. At present here lives a family having 10 permanent members.

At present there is an open space in front of the building (at south). At north there is two no’s seven storied buildings. There is 25’ wide road at east and a 4 storied building at west. The building has enough chance to get plenty of southern wind and day light at south. Initially the building was 3 storied; the 3rd floor was an additional floor. The building has load bearing brick wall structure and concrete slabs.
ANALYSIS OF AIR MOTION DUE TO WIND PRESSURE

Fig-07: Air flow in the indoor spaces, Source: Author
The study is based on the effect of wind flow through the southern windows and finding the real scenario of the spaces having southern exposure. For the research, the south facing spaces are divided into four areas, they are: study area 01, study area 02, study area 03 and study area 04. Detail field survey to find responses of the users of the residence has been done and the wind pattern that has found shown in fig: 07.

SUMMARY OF AIR FLOW AND VENTILATION CONDITION

<table>
<thead>
<tr>
<th>Study area</th>
<th>Ventilation condition</th>
<th>Thermal condition</th>
<th>User satisfaction</th>
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<tbody>
<tr>
<td>Study area 01</td>
<td>M</td>
<td>VG</td>
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<tr>
<td>Study area 02</td>
<td>E</td>
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<tr>
<td>Study area 03</td>
<td>E</td>
<td>VG</td>
<td>VG</td>
</tr>
<tr>
<td>Study area 04</td>
<td>NG</td>
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<td>NG</td>
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From the above chart, it is found that good thermal and ventilation condition is found at study area 02 and 03, that means the middle spaces of the total elevation getting the good situation but the spaces having windows at the end points are getting worse situation than the others. At study area 01 there is little chance of having cross ventilation because the 2nd window at west of the room remain closed for privacy concern. As the east and west are blocked, thermal comfort is good at study area 01. At study area 02 there is enough cross ventilation and also thermal comfort. So the user satisfaction is highest here. At study area 03 there is enough cross ventilation but thermal comfort hampers at afternoon due to
having window at west. This space has a large opening at south so it gets enough wind flow almost all day around. The worse situation is arriving at study area 04. Though it has a great chance for cross ventilation because of having window at corner position (at south and east), which is the best position for internal cross ventilation, is suffering much. There is not enough wind flow. Thermal comfort is also not so good because the room get heated at morning because of having an opening at east. As there is less wind cross-flow, the heat does not come out from the room and gets trapped and resulting warmer summer nights.

**Fig-08: Indoor spaces of study areas, Source: Author**

**FINDINGS ON THE BASIS OF LITERATURE REVIEW AND CASE STUDY**
Fig-09: Positive and negative wind pressure zone around the study building, Source: Author

The reason of having less ventilation of the study area 01 and 04 can be explained by the theory of wind pressure zone and wind suction zone. The both spaces are in negative wind pressure zone and the openings are in wind shadow and getting less wind flow, as it has been found in the literature review. Therefore it is found that all the south facing windows do not get positive wind pressure and good ventilation properties in indoor area unless it is positioned in positive wind pressure zone.

CONCLUSIVE REMARKS

From the case study in this research, the building seemed to be well ventilated but from a detail field survey and study on the occupants it is found that the entire south facing spaces is not getting the blessing of natural wind at a same rate just because of placement of windows and building orientation. The positioning of an opening at south is not the only solution for good ventilation of an interior space, Even when the window is oblique (at 45°) to the inlet opening of the same room (study area 04), ventilation condition may be not good. The position of the room along with openings is very important for comfort situation. Architects or designers should keep it in mind while designing a building to provide special kind of design solution for the openings placed at negative wind pressure zone. Environment friendly design solution is the basic need at present world. For designing a sustainable building, proper ventilation and natural lighting gets the first priority. Therefore, to design a well ventilated residence, each and every factors affecting ventilation should get equal importance to consider.

REFERENCES

B. Givoni (1969), Man, Climate and Architecture
Koenigsberber O. H. (1973), Manual of Tropical housing and Building
Markus T. A., Morris E. N., Buildings, Climate and Energy

Important!!!

If the responses and the revised manuscript are not submitted by the deadline, submission is deemed to have been abandoned. The rejection of the manuscript will be conveyed to the Authors. AJASE