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HUMAN THERMAL COMFORT ON THE BASIS OF AIR MOVEMENT AND VENTILATION: STUDY OF A SPECIFIC RESIDENCE

Masud Ur Rashid[1]

[1] Lecturer, Dept. of Architecture, Ahsanullah University of Science and Technology,
141-142, Love Road, Tejgaon I/A, Dhaka 1208, Bangladesh.
E-mail: masudurrashid@yahoo.com

Abstract- *Buildings are manmade three dimensional objects that incorporate with climate in various ways. Where someone lives in the maximum time of a day is influenced by some climatic factors in both micro and macro level. Thermally-comfortable environments depend on some environmental and personal parameters. Air movement and ventilation is one of the major subjects that influenced the human thermal comfort. The natural air movement pattern that comes towards the building has not a constant flow all over the living place. It is influenced by several structural conditions and space distribution. This paper is mainly based on an extensive study regarding the air movement pattern and ventilation over a specific residence. The main objective of this study is to realize the natural air flow and ventilation that happened through the living place which plays a vital role on this living place; also finding out the certain comfortable zones in the living places created by the airflow pattern.*

Keywords: Thermal comfort, Air movement, Ventilation, Airflow pattern, Climatic factors.

1. INTRODUCTION

The movement of air in a building affects the thermal comfort of occupants, influences the rates of heat gain or loss through the building envelope, and determines whether good-quality indoor air will be present. How a building designer lays out a building, chooses materials, defines building details, and participates in the construction process will influence the nature and magnitude of subsequent air movement in the building.

2. AIR FLOW AND ITS RELATION WITH BUILDING

2.1. Why should designers care about controlling air flow in buildings?

Thermally-comfortable environments depend on four environmental parameters and two personal parameters. The four environmental parameters are the dry-bulb temperature of the air surrounding the occupant; the relative humidity of the air; the (net) radiant exchange between the occupant and the surrounding surfaces; and the rate of air movement around the occupant. Further, the two personal parameters are the metabolic rate for the activity in which the occupant is engaged and the insulative value for the occupant's clothing ensemble. Thus, one determinant of whether a building occupant will feel thermally comfortable is how rapidly or slowly air moves in the vicinity of the individual. For example, on a day when the air in a building is warm and humid, air flow around an occupant can improve how comfortable the individual will feel alternatively, when interior air is cool and flows around an occupant, and then s/he will perceive the air motion as a draft and may be made uncomfortable by this motion. Second, air movement can induce significant heat exchange through the building envelope. For instance, the infiltration of cold air through the envelope can require that heat be furnished by some internal source to maintain the inside air temperature at a comfortable level. Thus, to reduce heating requirements for building operation, the infiltration of cold air should be curtailed. Conversely, cool external air will often be intentionally admitted into an internal space (by active air-handling systems) to offset — or dilute — heat build-up that results from internal heat production sources. Supplying good-quality air to building spaces is also a requisite for maintaining healthy and comfortable conditions.

2.2. What causes air movement in buildings?

The bases for air movement, both inside and outside of buildings, are temperature and pressure differences. When temperature differences exist between adjacent volumes of air, there will be accompanying air density differences between these volumes. Or, when an air temperature difference exists between a building surface and the air adjacent to this surface the density of the air close to the surface will be different than the ambient air. Where less-dense and more-dense volumes are present, the lighter air will rise and the heavier air will sink,

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causing air flow. Another example of air flow occurs when air in the atmosphere of the Earth moves (as wind) to a building surface. This air movement exerts a pressure on the building surface. This wind-induced pressure will be incrementally-greater than the ambient atmospheric pressure. If there are openings on the windward side of the building, the pressure difference (between the wind and the building interior) will cause outside air to pass in through the openings, producing air flow within the building.

2.3. Fundamental conditions involving air flow in buildings

There are basically three circumstances for which air flow in buildings merit study. First, air movement is generally present within building spaces and results from any one of several different mechanisms (or causes.) Second, air leakage through the building envelope commonly exists and occurs either by air passing from the exterior into the interior (as infiltration) or by air passing from the interior out to the exterior (as exfiltration.) And, third, air exchange takes place from one space to another and most often occurs through the operation of a heating, ventilating, and/or air-conditioning system (i.e., note that air exchange also happens between buildings and the external environment.)

The most pervasive of these causes are temperature differences between building surfaces and air volumes or between adjacent air volumes, effects induced by mechanical systems, and actions carried out by occupants while performing normal living and working functions. Also, air motion will result from intentional or accidental forces, and the motion can be caused by either active or passive devices.

3. RESIDENCE THAT HAS BEEN OBSERVED

3.1. Location

Tajmohal Road, Mohammadpur, Dhaka, Bangladesh. (Approximately 1300 square feet apartment at 3rd floor.)

Fig. 1: Direction of the air movement in the satellite image.

3.2. Positive properties

- South facing
- Play ground of the city corporation in front of the building.
- 8’ sweeper passage at the north.
- Linear veranda at the west which acts as shading device for the rooms.

3.3. Negative properties

- No window at the East.
- One bed room obtains south wind through staircase.
- Low height building at the west. So west side of the building gets west sunlight directly.
- It is the top floor of a 4 storied building. So heat gains from the roof.

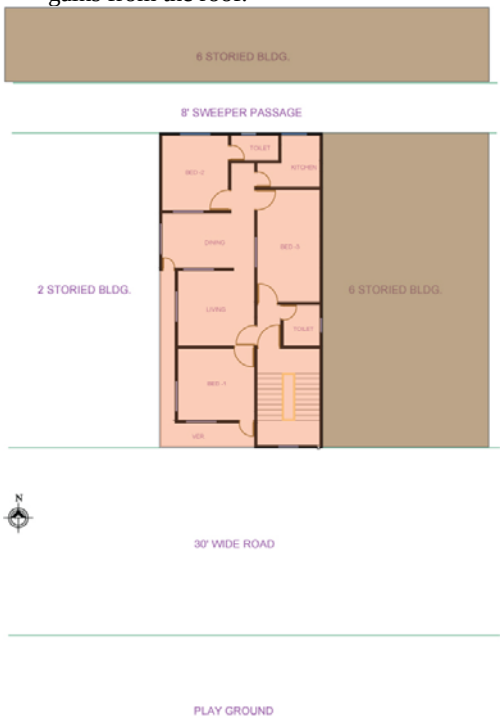

Fig. 2: Plan of the apartment and its surroundings.

Fig. 3: Photograph of the building.

3.4. Factors effecting air movement direction

- In front tree (shown in Fig. 3)
- The wooden framed window that acts as vertical fin when it is open.

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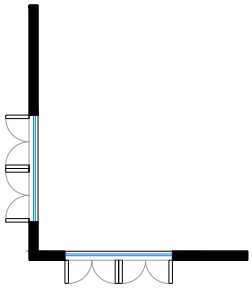


Fig.. 4: Window that acts as vertical fin when it is open.

3.5 Physical properties (materials)

- Wall: Locally made clay burn brick with CC plaster.
- Roof: RCC slab.
- Window: Glass with wooden frame.
- Door: Wood.
- Grill and railing: MS
- Color: Internal - light pink; External – white

4. STUDY OF AIR MOVEMENT AND THEIR COMPARISON

The main influencing feature of the air movement is the facing of the building. The in front playground of the city corporation plays a vital role on the air movement through the building. It is on the south of the building which is the main direction of air flow towards the building. The studied home is on the third floor. And the west sided building is only a two storied. Air flow occurred from the south west corner a lot.

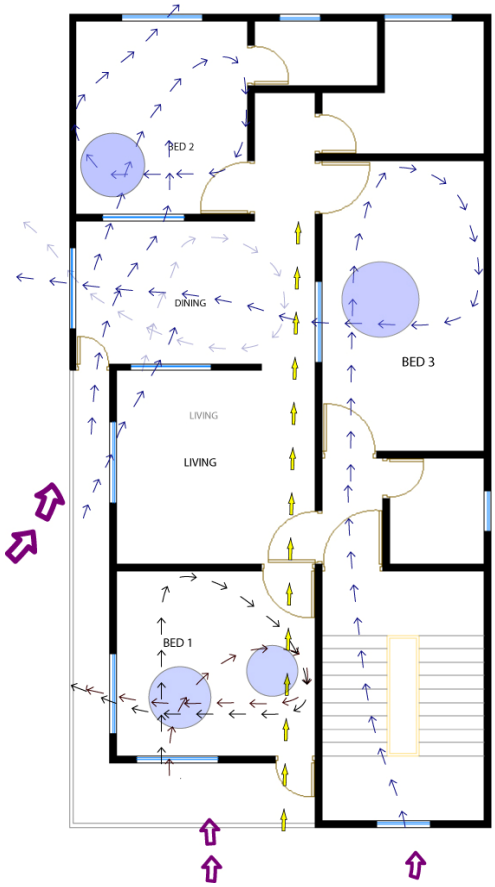


Fig.. 5: Direction of the air movement towards and through the building.

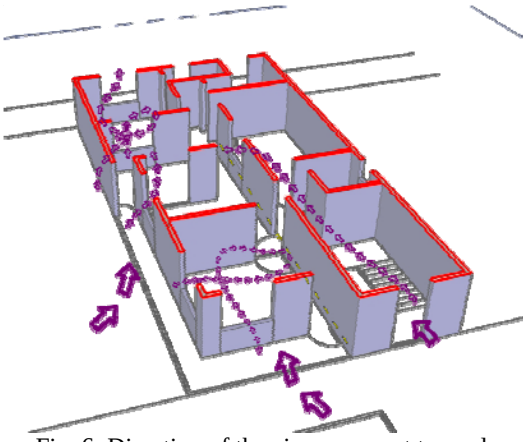
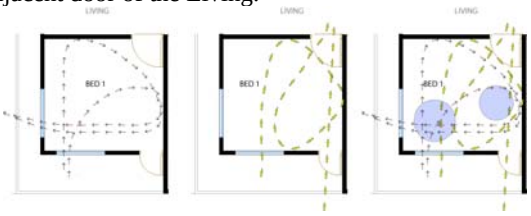


Fig. 6: Direction of the air movement towards and through the building.

4.1. Air Movement in different rooms of the Apartment

4.1.1. Bed 01: *Inlet:* South and west facing windows and south facing door. *Outlet:* West facing window and adjacent door of the Living.



a) b) c)

Fig. 7 a) Direction of air movement that comes through the windows b) Direction of air movement that comes through the door c) Direction of air movement that comes through the door and window.

4.1.2. Living: *Inlet*: West facing window and adjacent door of the Bed 01. *Outlet:* Adjacent door and window of the Dining.

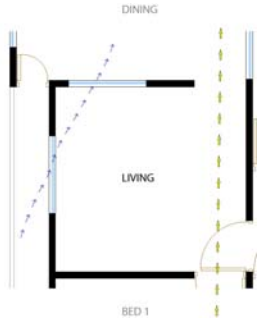


Fig. 8: Direction of air movement that comes through the door and window of the Living

4.1.3. Dining: *Inlet:* West facing window and south facing door from the veranda. Also from the adjacent door of the Living and window of the Bed 03. *Outlet:* Adjacent window of the bed 02 and west facing window.

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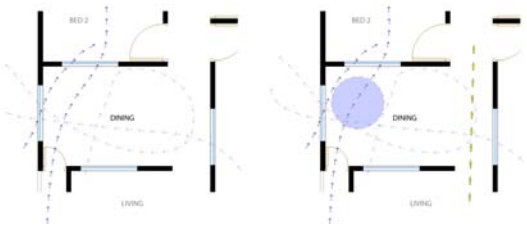

Fig. 9: Direction of air movement of the dining.

4.1.4. Bed 02: *Inlet:* Adjacent window of the Dining. *Outlet:* Exterior north sided window of the building.

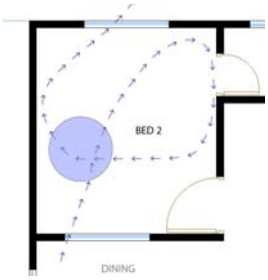

Fig. 10: Direction of air movement of the Bed 02.

4.1.5. Bed 03: *Inlet:* South sided overhead ventilation window. *Outlet:* Adjacent door and window of the Dining.

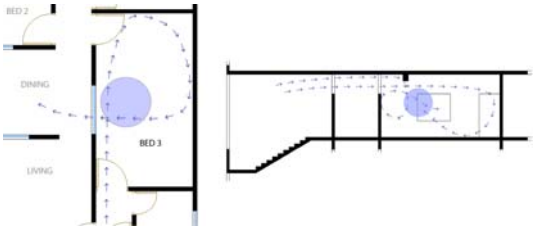

Fig. 11: Direction of air movement of the Bed 03. And Section through the entry door

5. STUDY OF AIR VELOCITY AND THEIR COMPARISON

Following Givoni [1] each room are divided by 3x3 grids. From each grid the air velocity is measured by mechanical device. The study has been done in a day when air flow is smooth and comparatively high. The results are shown in the following figure:

Fig. 12: The matrix of the air velocity (in m/s) in grids of the rooms. By blue color the comfort zones are indicated.

It is found that the air velocity is not same in each room and even in each matrix. The values are varied according to the air movement direction that is described into the previous section. The following graph indicates the average values of air velocity of each room.

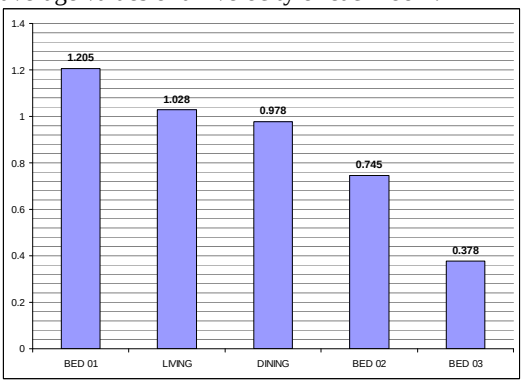

Fig. 13: Values of air velocity (m/s) of different rooms.

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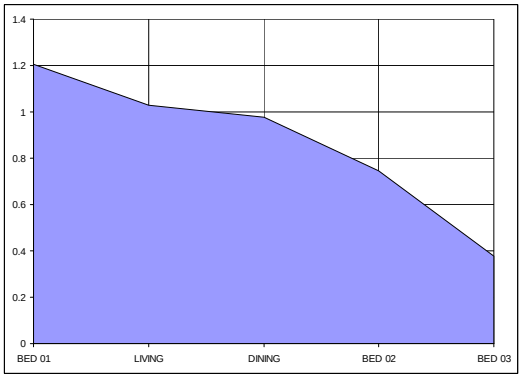

Fig. 14: comparison among the values of air velocity (m/s) of different rooms.

It is easy to find out the overall condition of the comfort level of each matrix from the following figure:

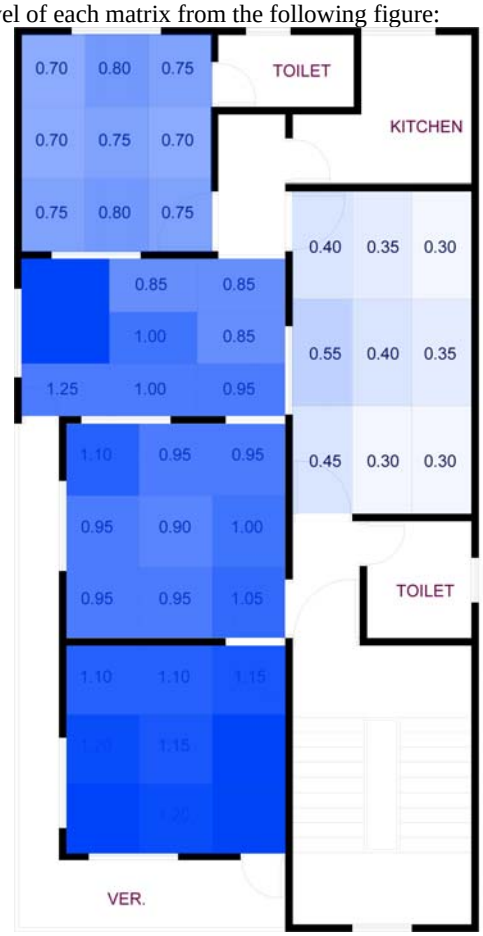

Fig. 15: By the darkness of the color the comfort level is indicated according to the air velocity.

5.1. Comfort zones of different rooms

5.1.1. Bed 01: Average air velocity: 1.205 m/s. Comparatively comfort zone (shown in Fig. 16)

Fig. 16: Air velocity in different matrix and the comparatively comfort zone of Bed 01.

5.1.2. Living: Average air velocity: 1.028 m/s. Comparatively comfort zone (shown in Fig. 17)

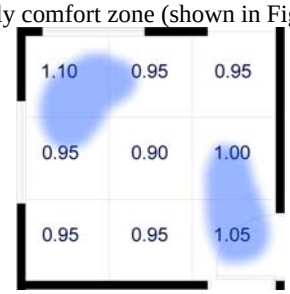

Fig. 17: Air velocity in different matrix and the comparatively comfort zone of Living.

5.1.3. Dining: Average air velocity: 0.978 m/s. Comparatively comfort zone (shown in Fig. 18)

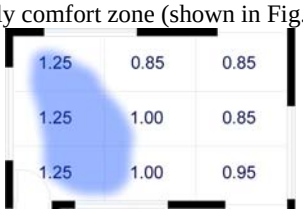

Fig. 18: Air velocity in different matrix and the comparatively comfort zone of Dining.

5.1.4. Bed 02: Average air velocity: 0.745 m/s Comparatively comfort zone (shown in Fig. 19)

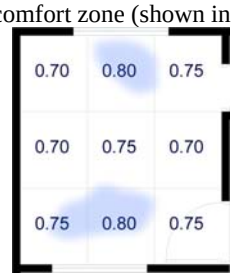

Fig. 19: Air velocity in different matrix and the comparatively comfort zone of Bed 02.

5.1.5. Bed 03: Average air velocity: 0.378 m/s Comparatively comfort zone (shown in Fig. 20)

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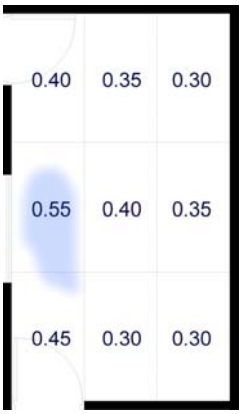

Fig. 20: Air velocity in different matrix and the comparatively comfort zone of Bed 03.

6. CONCLUSION

It is not the air movement and ventilation which only ensure the human thermal comfort in the living place. For realizing the actual comfortable zone into a home others factors should be included (e.g. DBT, WBT, building materials etc.). But it has a great influence in a hot-humid country like Bangladesh where humidity creates uncomforting to human. There are many factors that affecting the indoor air flow pattern are orientation, external features, cross-ventilation, position of openings, size of openings and controls of openings. By analyzing and making change in that factors may ensure the better thermal comfort in maximum place of the home.

REFERENCES

1. B. Givoni, *Man, Climate and Architecture*, Elsevier Publishing Company Lim., New York, 1969
2. D. Heerwagen, *Observing Air Flow In Buildings*, Department of Architecture, University of Washington.
3. Koenigsberger, *Manual of Tropical Housing and Building*, Orient Longman Ltd, Chennai, 1975
4. J. Straube, *Understanding and Controlling Air Flow in Building Enclosures*, University of Waterloo, Canada , 2001

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