TOWNHOUSES IN BANGKOK: ASSESSMENT AND RECOMMENDATIONS FOR NATURAL VENTILATION

David Mrugala

School of Architecture and Design

King Mongkut's University of Technology Thonburi

ABSTRACT

In view of contemporary building practices in the tropics where climatic factors are 'sometimes' neglected, this research paper puts forward some investigations and recommendations on what is appropriate for tropical buildings in the residential sector in regard of natural ventilation. One of the obvious failures of modern architecture in the tropics is the failure to accommodate the impact of climate. A good example of this failure is especially seen in the use of inappropriate materials, the excessive decoration of the building envelope and the insufficient comfort levels within living areas.

In view of the foregoing, the research paper emphasizes on wind simulations of natural ventilation to reduce energy consumption and increase comfort levels with more consideration on residents' health. A typical townhouse planning in suburban areas of Bangkok is used to simulate various shapes of roof and opening devices with the help of computer added software, Flovent, to generate results which will contribute to educational and professional discourse.

1. INTRODUCTION

For tropical regions, where the air temperature and relative humidity are generally high, the vernacular architecture of Thailand, such as the traditional Thai house, was designed to take advantage of prevailing winds. It was normally built with three notable characteristics: an elevated floor, a steeply pitched roof with long overhangs, and a large open terrace. The objective of this characteristics was to benefit from prevailing winds and to provide the occupants with comfortable space, usually in the lower part of the house. Natural ventilation has served as an effective passive cooling strategy (Tantasavasdi, Srebric, Qingyan, 2001).

However, lives in the past decades have changed dramatically. People tend to be more accustomed to air-conditioned environments. On the other side dense areas create a hot microclimate and discourage the use of natural ventilation: First due to site planning, where buildings block each other from prevailing winds and second due to inappropriate building design elements (Lerchner, 1991). The problems with current designs have prompted architects to rethink their designs, especially because of an increasing awareness of sustainability. People become concerned with the rising costs of electricity, especially when they have to pay utility bills for their own residences.

In suburban areas of Bangkok, where most of the new built townhouses lack of implemented passive cooling design elements, air-conditioning is used during the hot hours of the days. During the cooler hours, most people are still willing to open their windows and let fresh air in. Almost all windows in suburban townhouses can be opened (Tantasavasdi, Srebric, Qingyan, 2001).

The paper presented here is an attempt to investigate and problematize the flow of natural ventilation on the case of typical townhouses in Bangkok and include implementation of small changes in the facade and roof design with the aim to improve and assess ventilation. Investigations focus on the building envelope and its impact on the wind flow into and through the interior space. Natural ventilation is one factor that can contribute to conserve energy and to improve the quality of life of each resident living in townhouses (Lercher, 1991).

2. METHODOLOGY

For the research on natural ventilation, computer added software program - Flovent - was used to calculate and simulate the respective conditions based on existing planning. Each of the simulation steps required the analysis of the base case, the evaluation of the simulation results, and based on it the development of a strategy to improve existing problems in ventilation. The applied strategy with alternated designs was simulated again to verify the strategy and argumentation. In case of no improvement the applied steps of improvement are revised and simulated again.

Flovent sofware

Flovent sofware is a Computational Fluid Dynamic, CFD software provided by *MentorGraphics*. The software is able to simulate and predict air flow based on Navier-strokes equation, that focuses on continuity and conservation of mass flow, pressure, heat and momentum in Cartesian coordinates. To simulate airflow inside a building, the program requires following inputs: Building geometry with all openings, and external conditions, such as wind speed and wind direction.

Prevailing wind speed and direction play an important role for natural ventilation, especially for the ground level wind. Wind data of Bangkok recorded by *Thai Meteorological Department* in 2005-2007 is used for the simulations. According to the wind data the average reference wind speed at ground level is around 1.49m/s which is used as input parameter for the simulation process. The prevailing wind direction is from the South and according to the recorded data accounts for 42.7% which is almost 6 month per year mainly in the summer season. Another 19.4% of prevailing wind comes from South-West direction and 13.8% from West direction in rainy season. The South wind direction is the most frequent for Bangkok and therefore used for the simulations.

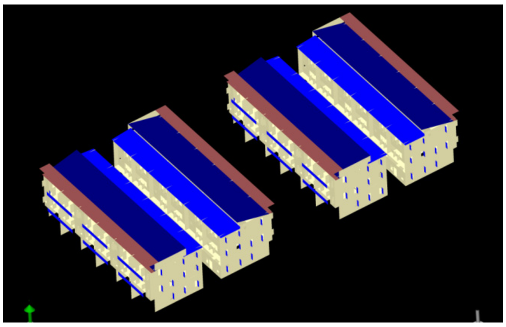

Figure 1: Model of townhouse units in CFD software

Four rows of townhouses (Figure 1) are constructed according to existing townhouse planning in Flovent software. The two rows are 13m separated from each other: 7m road and 6m setback. Front façades of the townhouses face North and South respectively. All doors and windows are fully open; 90 degree openings for casement windows and doors, and 100 percent opening area of sliding windows and doors.

To provide pure results and best possible evaluation, information on site typology, density of surrounding buildings and vegetation in windward side are excluded from the simulation as sometimes the wind flow can be blocked, its speed reduced or increased by other buildings, e.g. high-rise buildings.

Figure 2: Color bar shows different wind speeds in m/s

Simulation results are in graphical and tabular format. The wind speed in form of color scale and wind direction in form of vector arrows is illustrated. The color scale ranges from a low value of 0.0m/s in blue tone color to a high value of 1.83 m/s in red tone color (Figure 2).

Base Case - Typical Townhouse

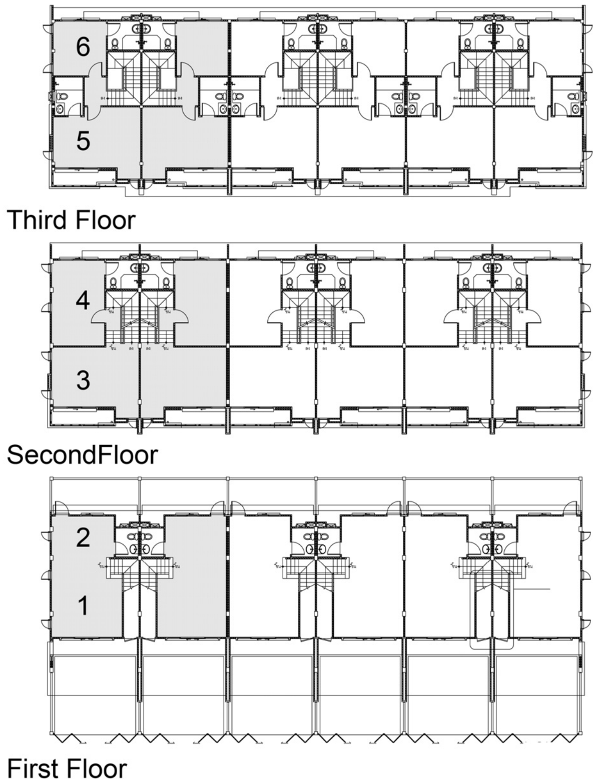

Figure 3: Floor plans (typical townhouse)

The base case for a typical townhouse (Figure 3) is according to existing development of real estate housing in Bangkok, such as SANSIRI and PRUKSA. A basic unit is 5.5m wide and 9.7m long; 6 units create a row of 40m width, restricted to the building code (SANSIRI, 2011). Each unit comprise of a living area (1), kitchen area (2), family room (3) open to the ground floor, bedroom 1 (4), master-bedroom (5) and bedroom 2 (6). In each floor a WC and bathroom respectively faces the back side of the townhouse with a small window. All floors are connected through an open staircase from which all rooms are accessible. On the East and West side, the corner units have additionally windows.

3. SIMULATIONS

The following analysis consists of three selected sections from various simulation attempts with small differences. The aim is to collect wind data, to compare and assess the wind flow behavior within the townhouse.

The base case (Figure 4) shows high velocity at the front facade, but little wind flow inside the townhouse. High turbulences appear at the front attic where the wind flow is diverted to the sky and to the sides. The decorative attic blocks and interrupts the flow. The first floor receives through the emerging positive wind pressure above less wind velocity and the wind diversion is increased visible in the lack of vectors a few meters away in front of the entrance. The occurred turbulences have an impact on the back of the house where negative pressure occurs and the wind changes suddenly the direction towards the house (second floor). Additionally wind flow emerges at the openings of the bathrooms, which are open to the bedrooms and circulation. The circulation on the third floor has almost no wind movement.

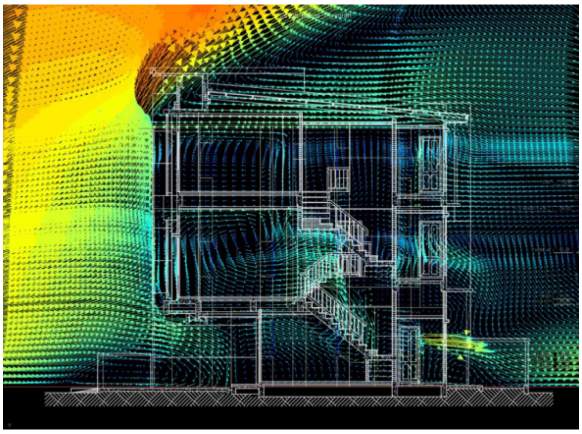

Figure 5: Base Case Flovent simulation

Figure 6 shows an alternated section including a roof with a skylight above the stairs, a higher attic and an open raised first floor. Additionally the front windows of the second and third floor are closed to simulate the implementation of the skylight. As in the base case, high turbulences occur in the area of the attic; the wind is diverted further away from the back of the townhouse. The raised first floor receives less velocity and high pressure emerges at the front entrance. Inside the townhouse, the simulation shows wind flow in the circulation area/stairs connecting the first floor with the added skylight. At the back of the house the turbulences disappear, and wind velocity decreases from yellow to dark green.

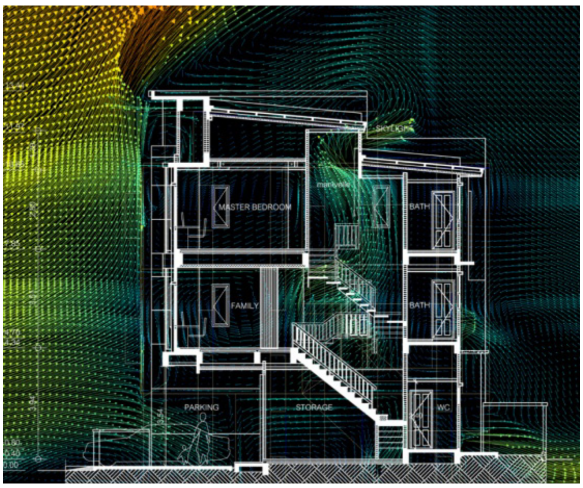

Figure 6: Skylight one roof slope Flovent simulation

Figure 7: Changes compared to the base case consist of a two stepped roof with a skylight, an open extended front attic and an open staircase on the second floor. All doors and windows are open. The simulation shows an increased wind flow on the ground floor, especially on the backside, and a higher velocity in the area of the circulation. The open extended attic traps and diverts the wind towards the skylight and the back where a soak effect (negative pressure) emerges, visible through the change of the color from green to yellow. Equal wind distribution appears in and outside of the townhouse.

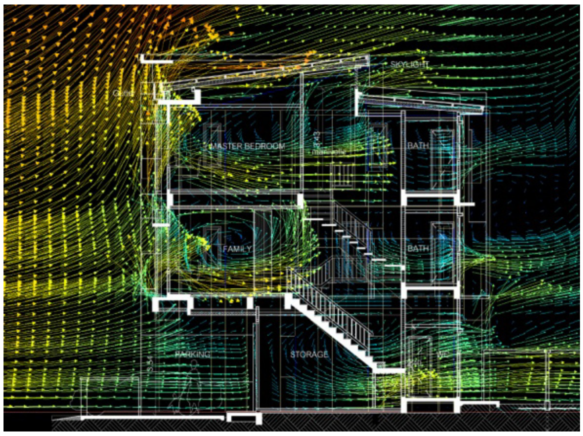

Figure 7: Skylight with two roof slopes

4.RESULTS

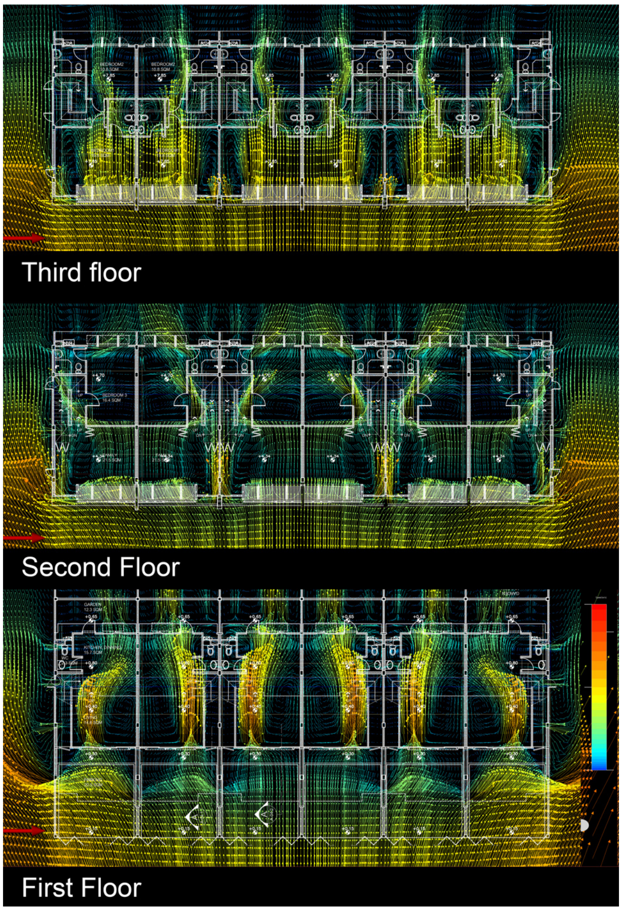

Figure 8: Floor plans (Refinement)

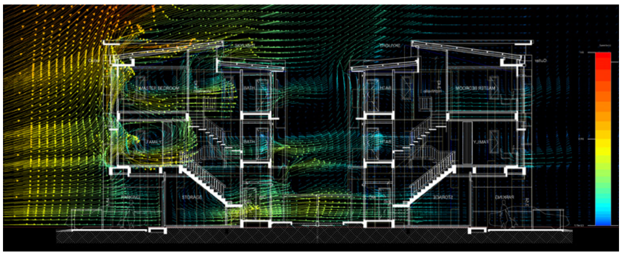

Figure 9: Section (Refinement)

The following presented result, Figure 8 and Figure 9, is the optimized section as in Figure 7: All townhouses within the row have an elevated first floor, an open attic and a two sloped roof with a skylight above the vertical circulation (stairs). According to the Analysis, the benefits of this changes have the most positive impact on the wind circulation in and outside of the townhouse. Less turbulences (positive and negative pressure) occur compared to the base case (Figure 6). As in Figure 7 described, the wind flow inside of the townhouse is equally distributed. The open attic at the front improves the wind flow, reduces the pressure and diverts the wind towards the skylight where a soak effect appears (negative pressure). The air from the circulation area in the third floor is pulled out and improves significantly the indoor air movement, with the potential of independent ventilation for each room, where in comparison with the base case, ventilation is only enabled through connecting both rooms: master-bedroom and bedroom 2.

First floor: (*Figure 8*) Due to the centered windows and the layout of the solid stairs, the result shows a narrow corridor of wind flow through the living and kitchen area. In comparison to the corner units, the center units have a higher wind velocity which is due to the positive pressure, the raised floor, and the lack of sideward turbulences appearing at front of the corner units.

Second floor: (*Figure 8*) The wind enters the family area through the balcony window and goes up the stair; cross ventilation through the skylight is possible, with an even wind distribution in the area. Differences occur at the small windows where a high velocity evolves and connects with the circulation. However the corner units have less benefit from the small windows as the outside pressure diverts the air away from the corner. Bedroom 1, in the back of the house has an uneven wind distribution, as it is connected through the small door only.

Third floor: (*Figure 8*) The master-bedroom has a very high and even wind distribution. It benefits from the extended open attic and the proximity to the open skylight. Although narrow, bedroom 2, in the back of the house has a higher velocity, as it benefits from the master-bedroom. The skylight enhances the effect and allows separate ventilation of each room and floor.

Side windows at the corner units seem to have little or no impact on the indoor wind movement, as on the outside the wind is directed away from the building.

5. CONCLUSION

Based on the simulations various cases were investigated with significant improvement of the overall wind flow in and outside of the townhouse. Compared to the typical base case, the simulations show that the wind flow does not depend solely on the size of the openings at the front of the building; Figure 8 and Figure 9 show clearly the benefits of a two sloped roof with an extended open attic and a skylight. Even with closed windows on the 2nd and 3rd floor, an improvement of wind flow from the 1st floor up to the 3rd floor is visible (Figure 10).

Other important aspects of natural ventilation that must be taken into account are the microclimate around the building, its envelope and the distance between the buildings and urban density. Lower temperatures of microclimate are recommended to lower prevailing wind temperature. Green areas and less 'hardscape' areas around the buildings are desirable, in order to benefit of noise protection from transportation, as well as less dust from the outside which will be brought in the course of ventilation.

REFERENCES

Tantasavasdi C., Srebric J., Qingyan C. , Natural ventilation design for houses in Thailand, Energy and Buildings 33 (2001) pp. 815-824

Lovins A.B., Air Conditioning Comfort: Behavioral and Cultural Issues, E Source, Inc. Boulder, CO (1992)

Busch J.F., A tale of two populations: Thermal comfort in air-conditioned and naturally ventilated offices in Thailand, Energy Buildings 18 (1992) pp. 235-249

Lerchner N., Heating, Cooling, Lighting: Design Method for Architects, Wiley, New York (1991)

David Mrugala graduated at the Karlsruhe Institute of Technology in Germany where he received his M.Arch./Dipl.Eng. (Architecture) in 2007. He is a lecturer at the School of Architecture & Design, King Mongkut's University of Technology Thonburi. Currently he holds the Chairman position of the undergraduate Architecture Program. His research focuses on material ecology and studies related to logic and abstracted architecture with the aim to develop design knowledge. He is also a practicing architect with ongoing projects ranging from small scale structures, housing, public buildings up to large scale projects.