ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 4, Issue 2, pp: (32-39), Month: October 2017 – March 2018, Available at: www.paperpublications.org

Natural Ventilation Strategies for Residential Buildings in Famagusta

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Abstract: **Natural ventilation, being the most environmentally friendly form of ventilation is very important in improving thermal comfort and indoor air quality in buildings. With the advancement in technology, there have been introduced many mechanical ways of ventilation as well. However, natural ventilation strategies hold many advantages over such mechanical solutions such as lower initial and maintenance costs. Due to the hot and humid climate of Famagusta, natural ventilation is therefore an effective way of improving thermal comfort and indoor air quality in residential buildings. This study aims to determine the most effective means of achieving natural ventilation and the most ideal orientation for residential buildings in the city of Famagusta, North Cyprus during the summer and winter periods.**

Keywords: **Famagusta, Hot and Humid Climate, Natural Ventilation, Residential buildings, Thermal Comfort.**

1. INTRODUCTION

With the increase in the number of residential buildings being brought up to cater for the needs of the locals and foreigners in Famagusta, it is important to ensure a comfortable living environment and a desirable level of thermal comfort within these internal spaces.

Natural ventilation is an ideal and suitable means in creating the desired levels of thermal comfort in indoor environments especially in places such as Famagusta where the climate is hot and humid. Although, new technological advancements have brought about new ways of ventilation such as mechanical ventilation in achieving similar results, natural ventilation strategy still holds various advantages over the former such as the incredibly low comparative first and operating costs. Secondly, natural ventilation generates cleaner air, therefore more sustainable. Installing mechanical systems in order to ventilate spaces in buildings adds up to the expenses of construction as well as use of electric power to generate these systems.

Natural ventilation uses simple principles obtained from nature. It is achieved using natural forces such as either wind or thermal buoyancy or in some cases both of them in order to regulate the building's indoor climate. Such forces are created by differences in temperature between the inside and outside of the building, thermal displacement within the building and prevailing winds.

The principle behind natural ventilation is that warm air rises and escapes the internal environment through openings and is replaced by cool air from outside, thereby lowering the internal temperature in the building.

Use of openings and windows in buildings can control the air change in order to achieve the desired levels of thermal comfort for the users. Simply opening and closing the windows would achieve the natural ventilation depending on the internal and external conditions.

Two main strategies are used to achieve natural ventilation. These are: cross ventilation and stack ventilation.

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1.1 Cross Ventilation:

Cross ventilation is driven by wind. The wind coming from the windward side creates a positive pressure at this point and the wind moving away from the leeward side creates a low-pressure zone at that point. This therefore creates a difference in pressure levels at the two sides and thereby opening windows at these two ends would force the air to move through the building due to pressure level difference. Depending on the placement, size and location of the openings, a number of results can be achieved.

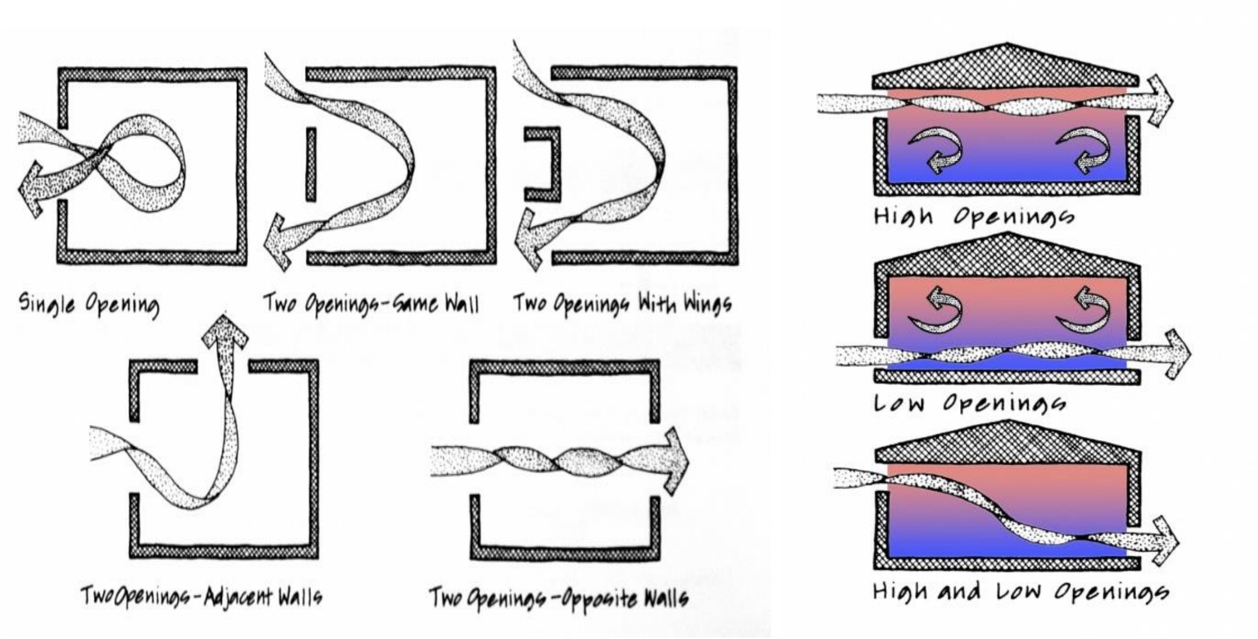

Fig. 1: Diagrams showing modes of Cross Ventilation [1]

1.2 Stack Ventilation:

Stack ventilation on the other hand is driven by thermal buoyancy. The difference in temperature of the inside air and the outside makes this work. Since warm air is lighter than cold air, it moves upwards. When windows are opened at different levels, the warm air inside the building would leave out through the top opening and the cool air from outside would enter the building through the lower opening to replace it.

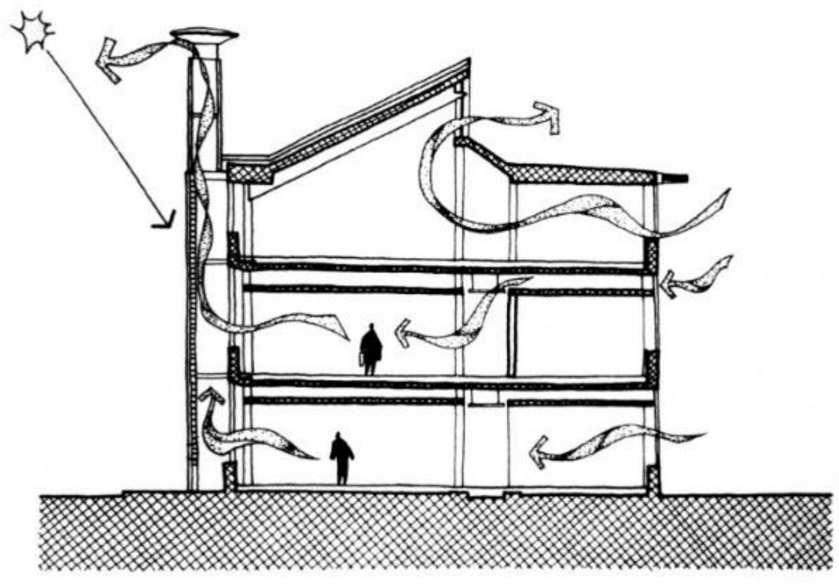

Fig. 2: Diagram illustrating Stack Ventilation [1]

ISSN 2393-8471

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The elements of natural ventilation include openings on facades (windows), chimneys, double-skin facades, atriums and ventilation chambers. It is possible to integrate more than one of these elements into a building depending on the form and organization as well as the design strategy and the environmental factors.

The keys to effective natural ventilation are the building orientation, the sizing and placing of the openings. The location and size of the openings is important on the windward and leeward side as the air flow is affected by such factors. Air flows from the windward side to the leeward side (positive to negative pressure zone).

Having smaller inlet openings than the outlet openings increases the speed of air flow. This is due to Venturi effect. This principle can be used to achieve the desirable levels of user comfort in buildings through natural ventilation.

2. LITERATURE REVIEW

For buildings in hot-humid climates, it is recommended to create openings in different walls to allow for cross ventilation for all rooms. [5] This would enable the free flow of air throughout all rooms in the building.

Window sizes and location would determine the success of the ventilation strategy in a building. The openings on either side of the building enable cross ventilation by creating different pressure zones. The factors that would affect the air flow therefore include the size, location and orientation of these openings.

The average interior air velocity is subordinate to the size and location of the openings, the angle between the wind direction and the inlets and velocity of the exterior free wind. [1]

Acceptable air flow velocity depends on the temperature and humidity of the environment. At temperatures below 33^{0}C, increase in air velocity increases the thermal comfort level. [4]

During the hot season, thermal comfort ventilation could have either of the following aspects; firstly, when the outside temperature is lower than the indoor temperature, ventilation can cool down the indoor air by replacing the outside air. It can also cool down the building structure. The second aspect is when the outside temperature is higher, ventilation can cause direct cooling on the human body for evaporation and convection.

There are two ways to enhance the level of human comfort in natural ventilation: direct and indirect physiological effects. These are known as 'Comfort Ventilation', which involves more wind through openings to increase the indoor airflow and results in the occupants feeling cooler. Direct approach is ventilative cooling and indirect approach is to improve the level of comfort by ventilating the building at night to cool down the interior, which is known as 'Nocturnal Ventilative Cooling'. [3]

Comfort ventilation is mainly applicable to regions and seasons when the outdoor maximum air temperature does not exceed 28-32^{0}C and where the diurnal temperature range is less than 10^{0}C. [4]

3. CASE STUDIES

Two residential buildings in Famagusta have been analysed as a part of the study. These buildings are being studied in their location in the sites, the orientation towards the wind and sun, the placement of windows, the plan design and placement of interior spaces. The locations and facades of the sample buildings are shown in the figures below.

Fig. 3: Map of Famagusta showing locations of Residential buildings used for the study

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Fig. 4: Facades of Uzun 10 Apartments [Author, 2017]

Fig. 5: Facades of Uzun 12 Apartments [Author, 2017]

4. METHODOLOGY

The research is based on observation and creating simulations using CoolVent software. The method combines energy and airflow calculations to simulate the results for the average climate conditions of Famagusta for the Summer and Winter period using the apartment buildings chosen for the study. In this study, residential buildings with different window types and sizes are oriented in different directions and the results generated.

The plans for the residential buildings used for the study are drawn and the buildings 3D modelled (shown in Fig. 6 and Fig. 7.) The simulations are done for the average climate conditions for the two seasons. The buildings' internal spaces are categorized into different zones.

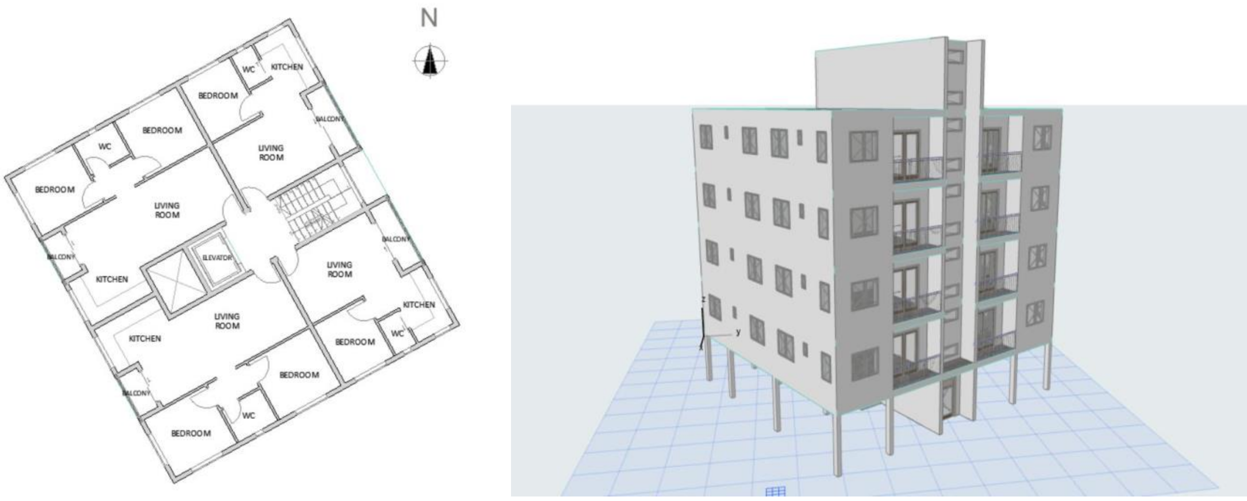

Fig. 6: Plan and 3D model for Uzun 10 Apartments (Author)

Fig. 7: Plan and 3D model for Uzun 12 Apartments (Author)

5. FINDINGS AND DISCUSSIONS

The facades for the apartment buildings being studied are very simple with window openings as the only natural ventilation strategy element. Most of the residential buildings in the areas consist of four to six storeys. The buildings analysed for the study are both 5 storeys. Both the buildings are oriented towards the North-East direction in their respective site locations and the general shapes of the buildings is rectangular. They consist of two and four apartment units on each floor and have been designed symmetrically. Most of the residential buildings in the surrounding are built very close to each other and this sometimes affects the natural ventilation.

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The results from the Summer and Winter simulations have been shown in a zonal form. The residential buildings have been divided into various zones which have been numbered. The results show the rate of airflow in these zones and spaces in the buildings and the general thermal comfort level for the occupants.

Figure 8 below shows the results of the simulation for Uzun 10 Apartments during the Summer and Winter seasons when the building is oriented in the North-East direction.

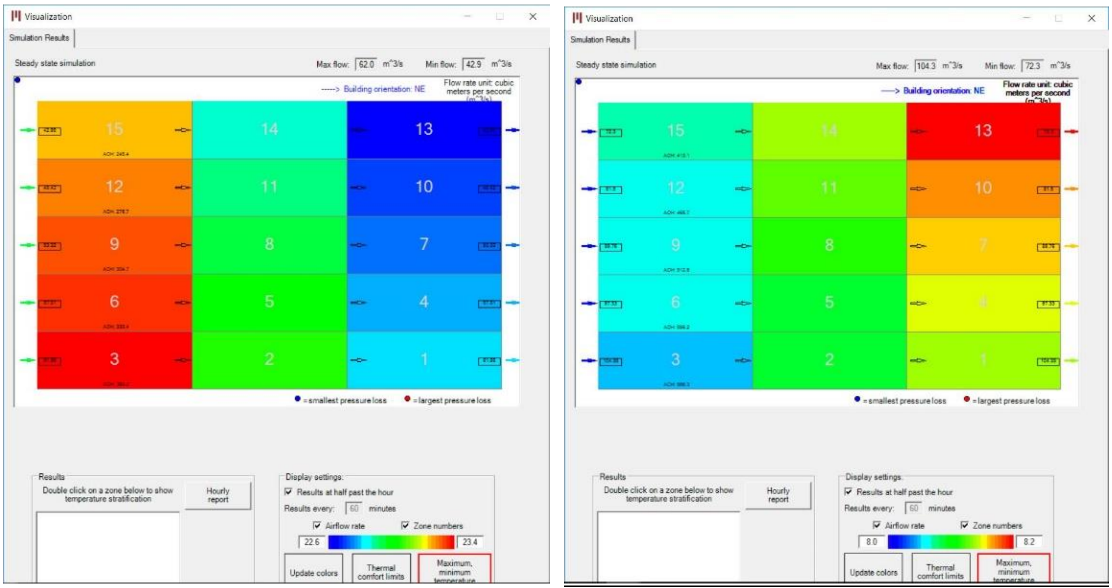

Fig. 8: Uzun 10 Apartment North East Orientation Summer (left) and Winter (right) simulation results [Author]

The blue colour on the zones indicate the smallest pressure loss while the red indicates the largest pressure loss in these spaces. The maximum and minimum air flow rates are indicated for a particular space within the zones. The assumption is that there are no buildings right next to the apartments being studied.

As seen from the results generated in Figure 8 above, during the Summer, the spaces on the South façade would heat up due to the direct sun rays through the windows.

When the building orientation is changed to the South direction, the following results (Figure 9) are seen.

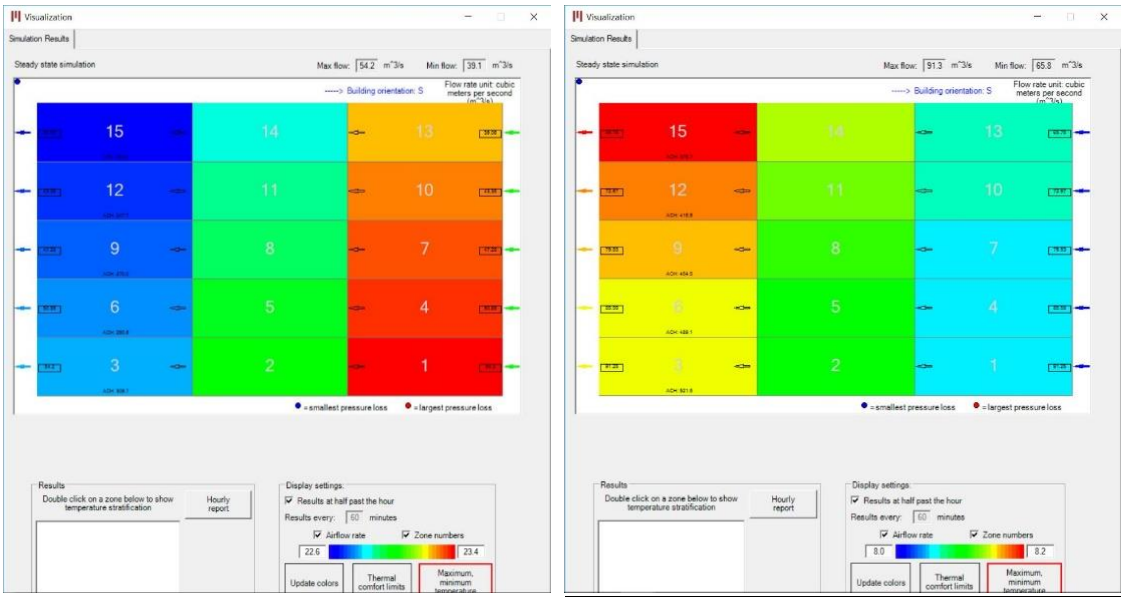

Fig. 9: Uzun 10 Apartment South Orientation Summer (left) and Winter (right) simulation results [Author]

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The opposite results are achieved when the building orientation is mirrored in the opposite South direction as seen in the figure above. The interior spaces on the south façade again heat up during the Summer season while it is cooler during the Winter.

The next step was to simulate the results for Uzun 12 Apartments for the Summer and Winter season in comparison with the other.

Figure 9 below shows the results of the simulation for Uzun 12 Apartments during the Summer and Winter seasons when the building is oriented in the North-East direction.

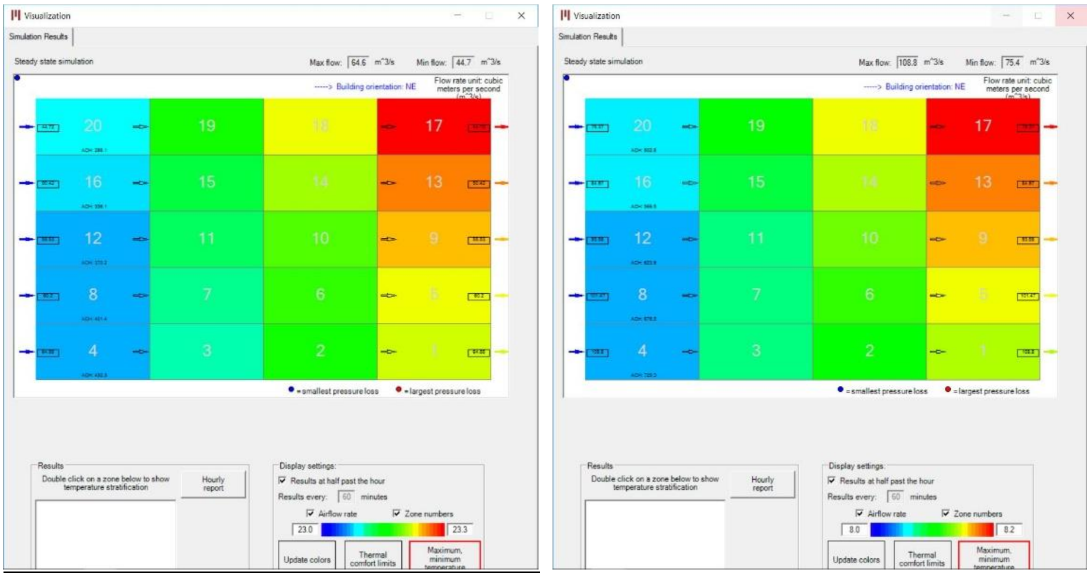

Fig. 10: Uzun 12 Apartment North East Orientation Summer (left) and Winter (right) simulation results [Author]

When the building's original orientation in the North-East direction is maintained, it is observed that the ventilation and thermal comfort levels are satisfactory both in the Summer and Winter periods. Since the building has just two apartment units on each floor as compared to the four units in the Uzun 10 apartment building, the units have both a South and North façade. This enables a convenient planning of interior spaces to allow for cross ventilation within the units and also sunshine.

When the building is oriented towards the South direction, the results in Figure 11 below are achieved.

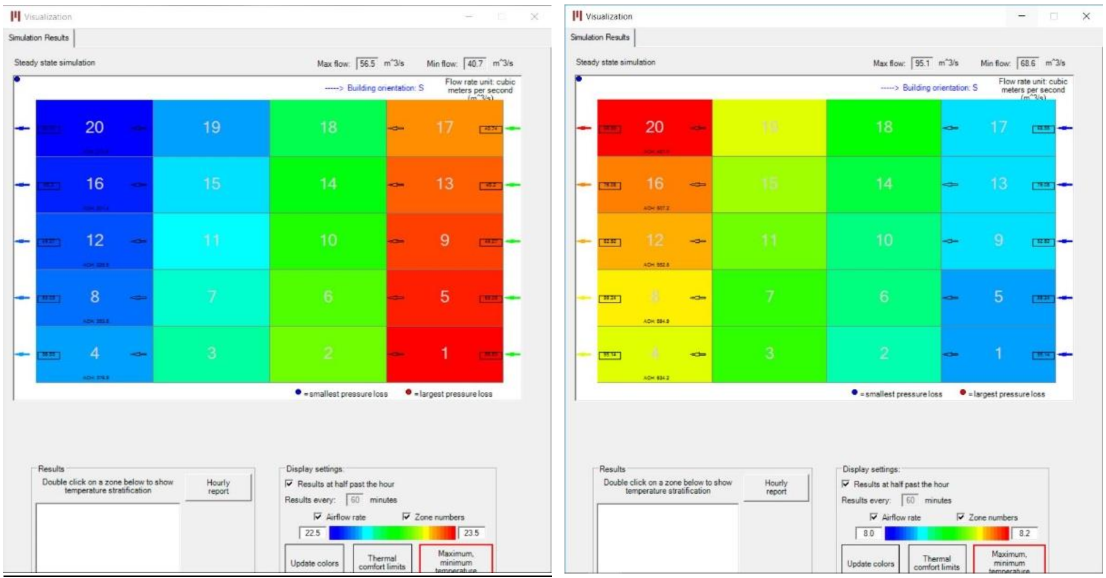

Fig. 11: Uzun 12 Apartment South Orientation Summer (left) and Winter (right) simulation results [Author]

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From the results, the changes can be noted when the building orientation is turned from the North East to the South direction.

During the Summer period, ventilation in the building would seem satisfactory due to the windows on the South-East, and East façades of the building.

However, the rooms on the south façade become very hot during the Summer season due to the direct sun through the windows. Due to some of these interior spaces heating up during the Summer period, it would be advisable to install sun-shading devices on the south facing façade windows so as to avoid excessive heating of these spaces.

From the research, it is determined that Uzun 12 apartment building is better ventilated and provides a more suitable thermal comfort level for the occupants. This is mainly due to having two units per floor thereby each unit having both a north and south orientation.

6. CONCLUSION

For residential apartments in Famagusta, it is important to have a floor plan in a way which would enable the units to have both a north and south orientation to achieve cross ventilation in summer and to have access to the sun’s rays in winter. Also, the space organisation for the common spaces and most used spaces in the building have to be planned with careful consideration to the sun and wind direction to enable proper ventilation and keep the spaces warm during the winter period thereby maintaining a suitable thermal comfort level for the occupants.

In cases where it would not possible to have cross ventilation in the apartments, the inclusion of a solar chimney would be a good alternative method of circulating the air on all the floors on hot days in Summer.

Bigger window sizes could also help in achieving better ventilation in the building during the Summer as well.

Orientation of the buildings and the distance between them should be organised in a way that they do not block each other from south and east wind direction and south sun radiation.

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