Natural Ventilation Performance of HDB flats

In order to fulfill this objective, field measurement of three different HDB flats, i.e. 3-Room flat, 4-Room flat as well as Executive maisonette were conducted. The three flat types selected represent the more distinct broad range of public housing accommodation in Singapore. 3 main parameters that include ambient air temperatures, relative humidity as well as air velocity were collected over an extended period of time for the three types of flats. The measurements were also carried out in two conditions i.e. with bedroom doors closed and opened in order to study their impact on natural ventilation. In order to have a better understanding of the airflow profile and distribution under these two different conditions, CFD simulations were also carried out. A comparison between the data collected from field measurements and that obtained from CFD simulations was also made to provide an insight into the accuracy of the CFD simulations and the issues that must be properly considered in the setting up of the boundary conditions for the simulations.

A comparison of the ventilation performance of the three flat types shows that 3-Room flat has the best performance, followed by 4-Room flat. One possible reason is that, the distance between the windows on opposite walls is shorter since the floor area is smaller. This helps to promote the flow of air from the windward opening to the leeward side, and better circulation of air is achieved within each room. On the other hand, the floor area and the volume of space in the 4-room unit is larger, the incoming air stream may not be effective in the distribution of air within the room since the distance for cross ventilation is now larger. The interior configurations and internal walls also provide resistance to the air flow path, and hence minimised the potential of effective cross ventilation. The maisonette unit has the worst ventilation performance. This is largely attributed by the 'closely packed' interior layout of the bedrooms on the upper floor which discourage air circulation.

Comparing the performance of the three flat types between open and closed door conditions, the results show that by opening the bedroom doors, the improvement vary from 92% (for maisonette), 31% (for 4-Room flat) to 11% for 3-Room flat. The improvement is mainly due to the fact that most of the bedrooms are single sided ventilated. Thus by opening the bedroom doors, cross ventilation can be enhanced thus improving the ventilation performance of all the three flat types. Maisonette unit shows the greatest improvement because though the bedrooms may be ‘clustered’ together, the layout allowed the rooms to reap the benefit of direct cross ventilation, with the inlets and outlets of bedroom 2 and bedroom 3 opposite to one and other. Two main observations can be made from the comparison of both ‘closed and opened’ door condition results. Firstly, cross ventilation under ‘door opened’ condition affects the air flow pattern, thus air velocity between the various rooms is generally more consistent and uniform with a lower disparity in the absolute velocity, since the flow of induced ventilation can be channeled freely throughout the apartment. Secondly, cross ventilation tends to increase the velocity magnitude when compared to that under ‘door closed’ condition, with the airflow circulating throughout the entire space.
A comparison of the different rooms within a unit also shows that in general, the living rooms and kitchens have better ventilation performance. This is primarily due to the potential of cross ventilation in these rooms. The results also show that the alignment of the windows on the opposite side of the living room/kitchen has important impact on the ventilation performance.

The study using the CFD simulations shows that the CFD techniques could provide the designers very useful information in terms of the impact of flat layout on the velocity distribution so that optimum designs can be achieved to reap the full potential of the natural ventilation. The case studies on the two flat types demonstrated that the 3-Room flat is better ventilated than the 4-Room flat in both situations when the internal doors are opened and closed. The simulation results also show that when the bedroom doors are closed, the ventilation performance of bedrooms is drastically affected in most cases. This is primarily due to the fact that the rooms become single-sided ventilated. The studies also show that by strategically orientating the bedroom door to face the direction where cross ventilation could occur, it can improve the airflow inside the room through better infiltration/exfiltration. The finding has demonstrated that CFD techniques have the potential to predict airflow to a reasonable degree of accuracy. However, the accuracy achieved was attainable only with a certain level of familiarization of the CFD program employed and elementary knowledge of fluids dynamics principles. Judgment on the part of the user is required both in the CFD modelling process and in the interpretation of the CFD results. In the CFD modelling process, users need to establish the correct boundary conditions such as the wind direction and magnitude. This could prove to be difficult at times and such error made in the CFD simulations will manifest in the CFD results.
Figure 1 Placing of Transducer for Data collection

Figure 2 profile of hourly average temperature for all units
Figure 3. Velocity distribution in 3-Room flat with internal doors closed (Case 1)

Figure 4. Velocity distribution in 3-Room flat with internal doors opened (Case 2)
Figure Error! No text of specified style in document. Comparison of velocity between CFD simulations and site measurements for 3-Room flat.