# vi. Paper Sessions

# Track 1: Smart Initiatives & Advanced Building Systems

# Session 1.3 Advanced Building Elements

# Filter Façade

Ferdinand OSWALD[a]

[a] *Institute of Architecture Technology, Graz University of Technology, Austria, ferdinand.oswald@at.tugraz.at*

**ABSTRACT**

The Filter Facade has the goal of reducing air conditioner split units usage in buildings by increase the comfort of interiors of residential high rises in subtropical climate regions with natural ventilation. It describes how to Optimize Building Renovation of Residential High Rise in Subtropical Region by modifying existing building structure to optimize natural ventilation.

***Keywords:*** *optimized building renovation of residential high rise in subtropical region*

## 1. INTRODUCTION

Over recent decades, residents living in modern residential buildings in tropical metropolises are increasingly using split-system air conditioners. The use and energy consumption of such systems in those regions are enormous, and especially the latter is a serious disadvantage in operating air conditioning systems. It is assumed that the additional energy consumption of seven-million metropolis Hong Kong alone will rise to 6.8 GWh per annum due to the use of ventilation systems. The South Eastern Chinese coastal region with its 150 million inhabitants requires an energy quantity of 145 GWh per year to cool their apartments with air conditioners. At the same time, these split-system air conditioners continue to heat up the urban environment with their warm exhaust air, discharging 40% of required cooling energy in the form of heat into the ambient air, thus also exacerbating negative effects of the urban heat island. According to statistical calculations, the worldwide urban population will almost double by 2050, increasing from 3.5 billion to 6.3 billion. Subsequently, energy required for cooling will almost double by 2050 as well. Given that the urban population cannot do without air conditioning, this forecasted growth is bound to pose a huge challenge to energy production and the carbon footprint. For future conurbations in sub-tropical regions, therefore, it will be of crucial importance to seek specific solutions for problems such as overburdened energy grids and local climate change. Reducing the use of split-system air conditioners is an urgent issue. It seems possible to increase comfort and reduce mechanical ventilation at the same time with the help of specifically natural ventilation systems for residential housing in tropical regions. Results from specific research projects and scientific measurement furthermore produced evidence that specific natural cross ventilation can optimize human behaviour for periods of up to 85 % of the year (e.g. Hong Kong) see Figure 1

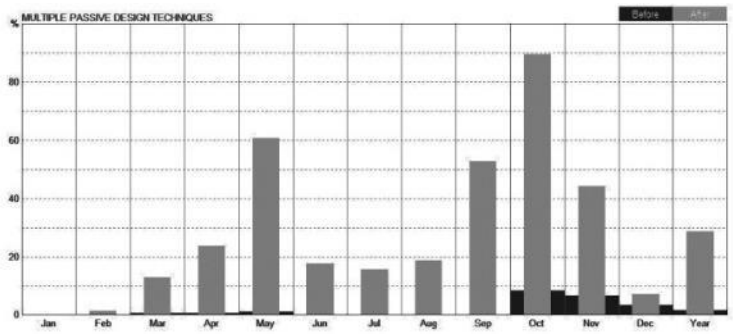


*Figure 1: Percentage of comfort throughout the year and per month achieved through natural ventilation in Hong Kong, data from psychrometric chart*

## 2. OPTIMIZED MODIFYING OF EXISTING HIGH RISERS

The floor plans of most residential high rises in tropical and sub-tropical regions do not allow for cross ventilation. This problem is demonstrated for the example of the Tung Lam residential high rise of the frequently used HARMONY type in Figure 2. Ventilation of the flats is possible through façade openings only but even the wind catchers (vertically disposed wind swords with an angle of 45° to the front end wall) do not work as expected. Cross ventilation across the corridors is impossible with this type of building, since walls of the flats confine the corridors on both sides. This results in blocking of the air flow at the access corridor.

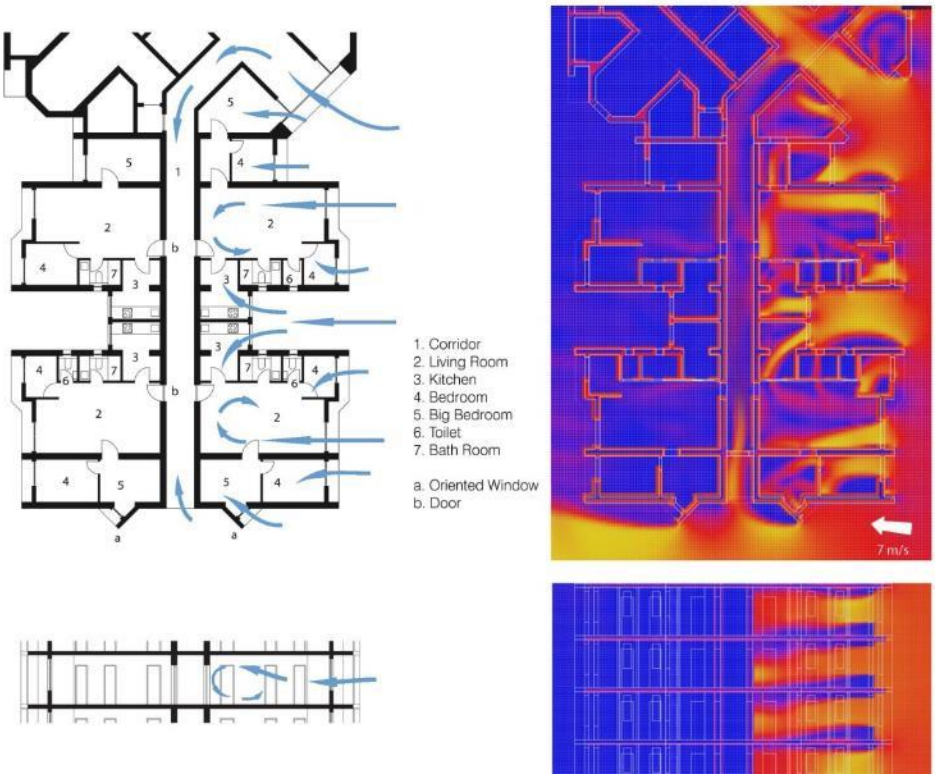


*Figure 2: Study of the air flow with the floor plan section of the HARMONY type Tung Lam residential high rise in Hong Kong. Sketch of the air flow and Computational flow simulation with colour coding of speeds: low – medium – high velocities in blue – red – yellow. Simulation software VASARI.*
*Left: floor plan, top: vertical cross section*

### 2.1 Modification

In a first step it was concluded that openings from the flats towards the access corridor will be a remedy. Possible openings can be the entry doors of the units but also additional skylight windows near the roof of the flats, favourably with adjustable cross section. Such configurations have proven to be effective in other buildings (e.g. Urban Tulou). Furthermore, the ineffective wind catchers were replaced by conventional bay windows with openable side wings. The most important measure was a change of the floor plan by an additional channel across the access corridor between the living units. For this purpose, the adjacent rooms in each unit must be slightly downsized. These modifications will allow cross ventilation from the façade openings to the windward units, and via the access corridor towards the leeward flats. All modifications are illustrated in the following Figure 3.


*Figure 3: Modified Building: Study of the modified building structure of the HARMONY type Tung Lam residential high rise in Hong Kong,*

However, with this configuration the addressed problem will appear: air from the windward apartments enters the corridor and then, instead of leaving through the openings of corridors, penetrates the apartments opposing the corridor (Figure 4). This would transfer potential contaminants from the windward apartments to the leeward apartments.

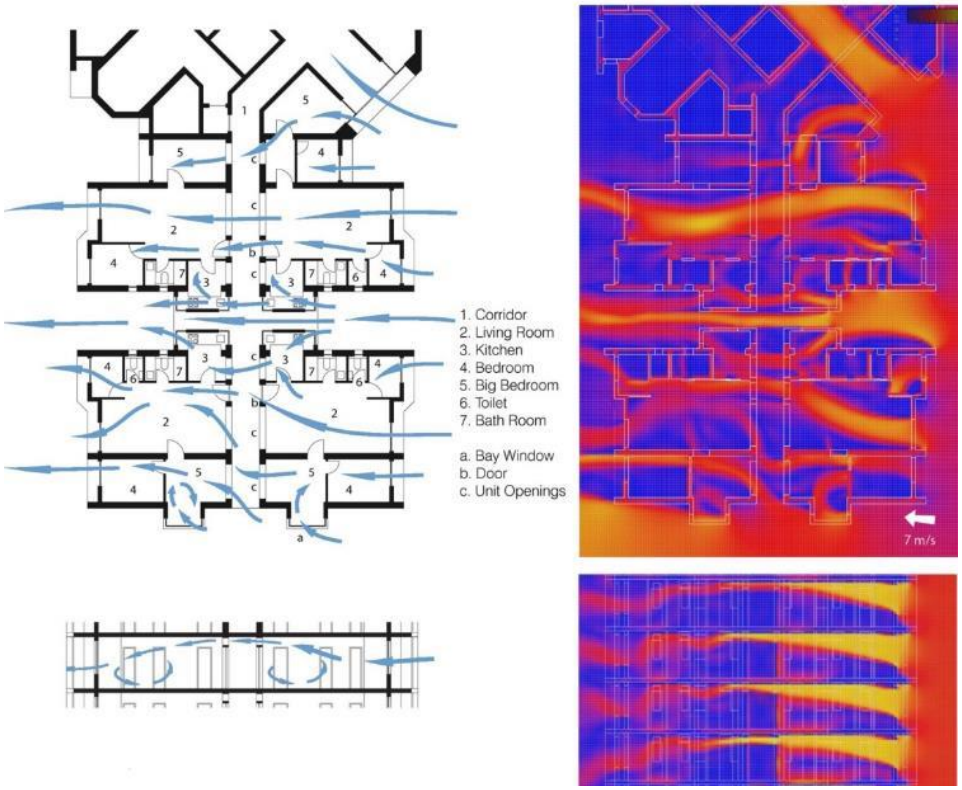


*Figure 4: Modified Building: Study of the air flow with the floor plan section of the HARMONY type Tung Lam residential high rise. Left: lines of the air flow in the floor plan. Right: Computational simulation of the air flow with colour coding of wind speeds: low – medium – high velocities in blue – red – yellow. Simulation software VASARI.*

In order to counteract this unpleasant behaviour the following concept optimization was developed.

### 2.2 Concept optimization

The openings of the windward apartments to the corridor are closed while the openings of the opposing apartments remain open. As can be seen in Figure 5, the simulation indicates that the flow field is strongly affected by this relatively simple modification. The ventilation of the windward apartments is ensured by inflow through the windward façade and suction from rooms adjacent to the additional "channel" between the apartments. Corner ventilation via the bay window with openable lateral wings supports the ventilation of the windward front-end unit.

The altered flow conditions provide enough airflow towards the corridor. Therefore, the leeward apartments are well ventilated by inflow through the corridor openings while the outflow is forced through the side windows adjacent to the "channel".

This concept will be evaluated with CFD and wind tunnel experiments in a proposed research project "Optimized Natural Ventilation". VASARI was used to show up the conceptual idea of the proposed study. This tool or its follow-up product may be used for the following project in a preliminary manner to get a first impression.

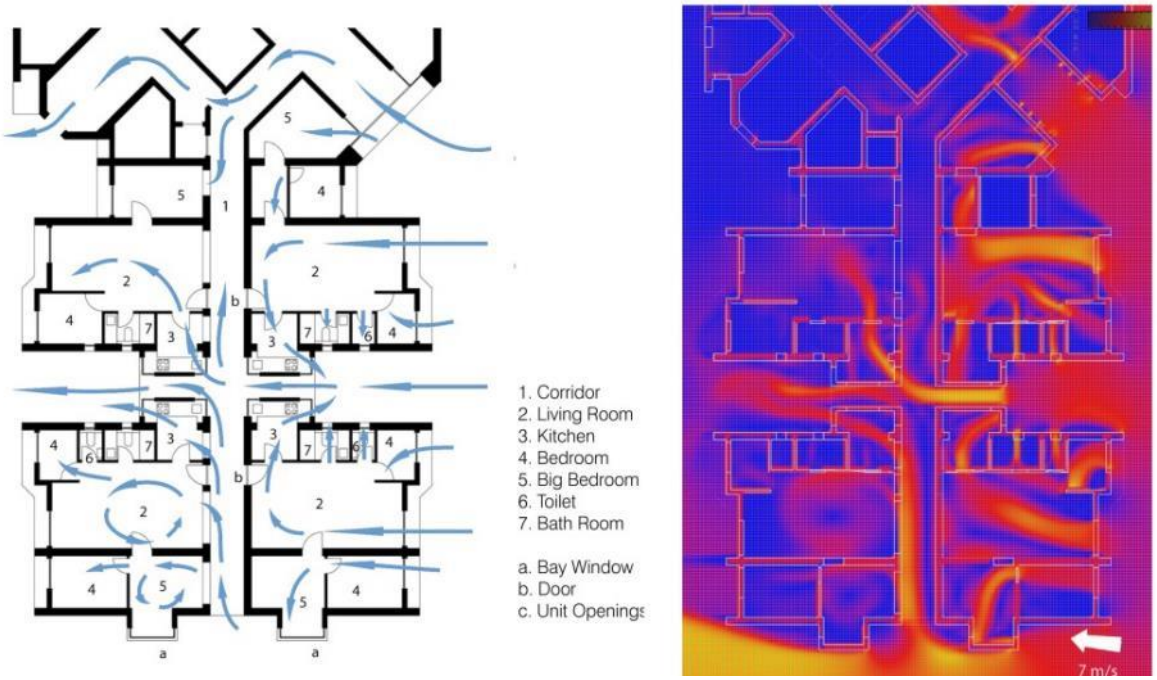


*Figure 5: Optimized Modified Building: Study of the air flow with the floor plan of the HARMONY type Tung Lam residential high rise. Left: lines of the air flow in the floor plan. Right: Computational simulation of the air flow with colour coding of wind speeds: low – medium – high velocities in blue – red – yellow. Simulation software VASARI.*

## 3. PROJECT OPTIMIZED NATURAL VENTIALTION

The aims of the research project "Optimized Natural Ventilation" are to promote conceptual and methodological principles in developing architectural concepts to guarantee increased comfort by means of natural ventilation in residential buildings, not just in tropical and sub-tropical regions. The project will deliver underlying basic information enabling the development of specific openings for large cities. In addition, criteria accounting for problems such as air pollution and noise load will also be fulfilled. The project aims to identify optimum airflow dynamics and the highest possible air change rate (ACH) with account for urban environment, floor plan and façade of a residential building. Concepts will be assessed and results compared with wind tunnel experiments and computational fluid dynamics, thus establishing the best combinatorial models. The hypothesis is that there exist optimized conditions for natural ventilation for residential rooms accounting for the urban building arrangement, floor plan configuration and façade openings.

Hong Kong is regarded as a vanguard of innovative implementations in residential housing throughout continental China, providing widespread basic knowledge and innovative developments to other Chinese metropolises. The derived results will be applied on-site on a 1:1 scale mock-up in realistic conditions, as well as tested and compared

to the elaborated basics by measurements. Implementation will be realised in the course of cooperation`s between European and Asian institutions.

A further step will be to apply the results from this project to future research activities. A strategy for commercial exploitation of the project results will be an cooperation with OEMs of window and filter systems. Those companies have the aim and possibilities to develop and certify the opening systems for the markets in Asia and Europe.

## REFERENCES

[1] Siwei Lang: “Progress in energy-efficiency standards for residential buildings in China”, in: Energy and Buildings 36/12 (2004), pp. 1191–1196.
[2] Population development in cities 2050. Source: McKinsey 2013.
[3] Office of Dissemination, China Statistics Press, National Bureau of Statistics of China, China Statistical Yearbook 2011, Beijing 2012, pp. 93.
[4] Wang L.: „ Applying Natural Ventilation for Thermal Comfort in Residential Buildings in Singapore “, in: Architecture Science Review Volume 50.3 (2007), pp. 224-233.
[5] Weather Tool 2001, © Autodesk, Inc. 2010; Weather data Download, U.S. Department of Energy, report on the data (STAT) and ASHRAE Design Conditions Design Day Data file (DDY).
[6] Research Project in Cooperation with the Hong Kong Housing Authority © Ferdinand Oswald, Institute of Architecture Technology, TU Graz, Austria 2013.
[7] Oswald, F., Reduce A/C - Reducing the utilisation of air conditioning in high-rise buildings in subtropical and tropical climate regions, 2015, Graz, Austria, (p 681) p. 548-568.