Reflection P4: Wind Tunnel City

Air quality is an important topic for many metropolises. High density high-rise environments have significant impact on the air quality and use of space. In Hong Kong it has resulted in poor air quality; a network of podia with supporting facilities; with a mixed cultural background of East and West. The inhabitants face high air pollution levels causing missing work days, health problems, school absences and discomfort (Environment Bureau, 2013:3).

In 2003 Hong Kong experienced an outbreak of Severe Acute Respiratory Syndrome (SARS). (BBC World Service, 2012), This lead to a study, initiated by the government, on how to increase the quality of the built environment. Which resulted in an Air Ventilation Assessment (AVA) Method based on creating breezeways (fig. 1) to serve as a guideline for new developments. In Hong Kong the concentration of air pollution is not only influenced by the emission of pollutants but also by weak wind conditions (Ng, 2009:1) and a dense urban fabric which reduces the dispersion of air (Edussuriya, 2006:212).

Within Hong Kong, Mong Kok is the area with the worst air quality and the least available wind. Therefore, the research question is: How can urban ventilation in Mong Kok, Hong Kong, be triggered by architectural design? Aiming at designing sustainable high-rise in a high density city with a healthy urban climate; taking in account both social and environmental issues; with the intention to contribute to the progression in this field of research.

Through literature study I gained insight about current problems and the available knowledge, which enabled me to build upon what's known and to put my research in context. Rhino has been used as a design tool. OpenFOAM (Open Field Operation and Manipulation) and Paraview have been used as research tools. Open FOAM is a Computational Fluid Dynamics program used to model, calculate and evaluate air flow. Paraview is used to visualize the data generated by Open FOAM. Sketches and models are used to explore spatial arrangement. This setup led to a design by research.

I did not use Grasshopper for evaluation as I intended to do. There was no immediate need to use grasshopper although I still think it can be a helpful tool for a more detailed and faster evaluation. The use of grasshopper within this field could be studied in future research.

My graduation project is based on the peer reviewed papers of R. Yoshie (2007) and S.H.L. Yim (2009). Yoshie's wind model functions as a benchmark and makes the comparison between wind tunnel research and computer models. Yoshie's wind model in combination with Yim's wind model of Hong Kong as it was in 2009 resulted in a new wind model for present day Mong Kok, Hong Kong (fig. 2).

The answer of the research question and the result of the research is based on a principle to push the wind down into the city by having a higher Frontal Area Density (fig. 3 and 4) at the top of high-rise buildings. This, in contrast with creating breezeways, results in smart densification and better air quality which is in line with the social and economic growth of Hong Kong.

Evita M.M. Pronk 4010965
Mentors: R. Notrott, G. Bracken, H. Plomp, L. Aanen
En op consult basis: Zhou Yu, Ying Ying Man-Ip, Reinier Maas en Bas de Bont.
Figure 1: Breezeways are for fresh air to penetrate into the city, requiring to reduce building footprint.

Figure 2: Yoshie's wind model in combination with Yim's wind model of Hong Kong as it was in 2009 resulted in a new wind model for present day Mong Kok, Hong Kong.
Figure 3: Smart densification can lead to better air quality at street level.

Figure 4: By using Frontal Area Density in a smart way the wind can be pushed down into the city for better air quality.
Graduation Plan: Architecture

**Personal information**
Name: Evita M.M. Pronk
Student number: 4010965
Address: Gevers Deynootweg 78
Postal code: 2586 BN
Place of residence: Den Haag
Telephone number: 06-18567932
E-mail address: evita_cindy@hotmail.com

**Studio**
Teachers: R. Notrott, G. Bracken, H. Plomp, L. Aanen
Argumentation of choice of the studio: The Explore Lab studio gives me the opportunity to follow my fascination and is more research oriented than other studio's.
Theme: Urban microclimate and the design of outdoor spaces

**Title**
Title of graduation project: Wind Tunnel City

**Product**
**Problem statement**
High density high-rise environments have significant impact on the air quality and use of space. In Hong Kong it has resulted in poor air quality; a network of podia with supporting facilities; with a mixed cultural background of East and West. Within Hong Kong, Mong Kok is the area with the worst air quality and the least available wind. Therefore, the research question is: How can urban ventilation in Mong Kok, Hong Kong, be triggered by architectural design? By using CFD (computational Fluid Dynamics) a comparison of the current situation and the design proposal can be made to conclude if the air quality has improved.

**Goal**
Sustainable high-rise in a high density city with a healthy urban climate; aiming at both social and environmental sustainability.

**Process**
**Method description**
Through literature study I gain insight about current problems and the available knowledge, which enables me to build upon what's known and to put my research in context. Rhino and grasshopper are being used as design and evaluation tools. OpenFOAM (Open Field Operation and Manipulation) and Paraview are research tools. Open FOAM is a CFD program used to model, calculate and evaluate air flow. Paraview is used to visualize the data generated by Open FOAM. Sketches and models are used to explore spatial arrangement. This setup leads to a design by research.

**Literature and general practical preference**
**Social**
Reflection
Relevance
Air quality is an important topic for many metropolises. Hong Kong is no exception. The inhabitants face high air pollution levels causing missing work days, health problems, school absences and discomfort (Environment Bureau, 2013:3).

In 2003 Hong Kong experienced an outbreak of Severe Acute Respiratory Syndrome (SARS). (BBC World Service, 2012), This lead to a study, initiated by the government, on how to increase the quality of the built environment. Which resulted in an Air Ventilation Assessment (AVA) Method to serve as a guideline for new developments. Hong Kong focuses on dealing with weak wind conditions (Ng, 2009: 1). The concentration of air pollution is not only influenced by the emission of pollutants but also by a dense urban fabric which reduces the dispersion of air (Edussuriya, 2006:212).

My graduation project is based on peer reviewed papers with the intention to contribute to the progression in this field of research.

Time planning
P1: Problem definition; influence of the high-rise on the city.
P2: Urban aerodynamics; influence of the city on high-rise.
P3: Building aerodynamics; focusing on the scale of the building.
P4: Integrated sustainable design: urban aerodynamics, building aerodynamics with a focus on building configurations, floor plans, apartments.
P5: Finalizing the project.