DECLARATION

" I declare that I have read this extract and according to my opinion,
this extract is enough to fulfill the purposed for award of the
Bachelor Degree in Mechanical Engineering
from the aspects of scope and quality"

Signature : .....

Supervisor : Mr Cheng See Yuan

Date : 26/05/06

THE EFFECT OF WINDOW CONFIGURATION AND POSITION ON CROSS VENTILATION IN A ROOM; CFD METHOD

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This report is submitted to the faculty of Mechanical Engineering as a partial to fulfillment of the award of Bachelor Degree in Mechanical Engineering

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May 2006

DECLARATION

" I declare that this report entitled '*THE EFFECT OF WINDOW CONFIGURATION AND POSITION ON CROSS VENTILATION IN A ROOM; CFD METHOD*' is the result of the work of myself except for the references which I had clarified the sources"

Signature :.....

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Date :26/05/06

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ABSTRACT

Ventilation is one of the important options in providing thermal comfort in buildings. Effective distribution of fresh air within an occupied space is of considerable importance in securing good indoor air quality, (IAQ). In natural ventilation systems, the fresh air is often provided through the opening of the window. The objective of this study is to predict the air flow characteristics via various window configurations and positioning. The air circulation inside an enclosure (room) with different opening was studied by mean of using the commercial Computational Fluid Dynamic (CFD) program CFX 5.7.1. The result of the standard K- ε turbulence model is compared to previous journal that done by Per Heiselberg, Kjeld Svidt, Peter V.Nielsen, 2001. *Characteristic of airflow from open windows.* Alborg University, Denmark. This studied described the results of a simulation that performed on four different window types to determine the characteristic of the air flow in the room where the best window design is the sliding with bottom hung window at the top because it has big opening area and give more air circulation inside the room. The comparison between the computational and physical paper show good and acceptable agreement.

ABSTRAK

Pengudaraan ialah salah satu cara untuk mengekalkan keselesaan dalam sesuatu bangunan. Penyebaran udara di dalam kawasan yang di diami dianggap penting bagi mengekalkan kualiti udara (IAQ). Dalam pengudaraan semulajadi, udara segar diperolehi daripada pembukaan tingkap. Tujuan kajian ini dijalankan adalah untuk mengetahui ciri-ciri pegudaraan di dalam sesebuah bilik dengan rekabentuk tingkap dan kedudukan yang berbeza. Pengedaran udara di dalam bilik tertutup dengan pembukaan tingkap yang berbeza dikaji dengan menggunakan salah satu perisian di dalam 'Computational Fluid Dynamic' iaitu 'CFX 5.7.1. Keputusan 'Model Standard turbulence' dibandingkan dengan data eksperimen yang dijalankan sebelum ini dengan menggunakan model asal tingkap dan bilik. Kajian ini menunjukkan keputusan yang di jalankan terhadap empat jenis tingkap untuk menentukan ciri-ciri pengaliran udara di dalam sesuatu bilik di mana tingkap gelongsor digabung dengan tingkap tolak adalah rekabentuk yang terbik kerana ia dapat memberikan lebih pengaliran udara. Perbandingan yang dibuat antara keputusan simulasi dan data kajian yang di jalankan sebelum ini menunjukkan keputusan yang hampir sama.

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SYMBOLS	DEFINITION
A	Area
V	Velocity
Q	Air flow rate (capacity)
K	Kelvin
C_c	Contraction coefficient
C_v	Velocity coefficient
C_d	Discharge coefficient
U_x	Mean wind speed
V_{theo}	Theoretical velocity
CV	Cross ventilation

GREEK SYMBOL	DEFINITION
ρ	Density
ε	epsilon

SUBSCRIPT	DEFINITION
min	Minimum
maks	Maximum
x	x – axis
y	y- axis
c	Cross section

APPENDIX

CHAPTER 1

INTRODUCTION

The ventilation in a cell room of low cost house is occasionally studied in order to improve the working condition for it to operate. Circulation of air inside the room that has good ventilation will give the good health to the user because it provides fresh air. By using natural ventilation, the energy (if using mechanical ventilation such as fan) can be saved. Because of this, it inspired me to do the research on air flow through window design by using natural ventilation system. Effective distribution of fresh air within an occupied space is considerable importance in securing thermal comfort and good indoor air quality (IAQ).

In mechanically, ventilated spaces ranging from small room to large buildings, effective air distribution is generally achievable through good design and operation of air distribution systems. The distribution of air inside the room is inextricably linked to indoor air quality, IAQ. This is important due to thermal comfort. Airflow within a room affects the emission rate at which contaminants emit into the air from sources within the room, primarily by the room airflow. The amount of air introduced into the room, the quality of that air and the way the air is diffused into the room are important factors determining the conditions that will result.

1.0 VENTILATION

Ventilation of a building is the process by which indoor air is exchanged with outdoor air and thus by different possible means. It has three function such as the first used to renew indoor air and remove the air pollutants (created by metabolic functions of occupants of emitted by other sources), in order to insure acceptable air quality for the health and comfort of the occupants. It also contributes to the protection against damage due to condensation indoors. Finally, it acts on thermal comfort (free cooling, bringing in cooler fresh air). Air movement in a building or a room is normally caused by thermal or momentum differences between the warm and cold zone (natural convection), by mechanical ventilation system (forced convection) or by a combination of both. Natural convection is very commonly in a room. Ventilation systems are usually classified in two main categories: natural and mechanical ventilation.

1.0.1 Natural ventilation

- is based on two driving forced: wind pressure and stack effect (temperature different), on which therefore the ventilation rate and air flow pattern depend strongly. Air flows in and out through provide openings : open able window, small air vents in window, trickle ventilators located in the in the window frame, passive or variable air inlets, vertical ducts called passive stacks. Careful design is required for a satisfactory ventilation process. It is most suited to buildings located in mild climates, away from inner city locations.

1.0.2 Mechanical ventilation

- is relies on the use of one or more fans to extract and or introduce air from or to a space : the air may be mechanically exhausted while naturally introduced or vice versa or both supplied and extracted by mechanical means (balanced ventilation). Systems relying on mechanical device are therefore capable of providing controlled ventilation to a building. The exhaust and or supply systems may be local or centralized. In which case, air is carried out and or in spaces.

through a ductwork. The air flow rate is controlled. It may constant, but may also rely on demand. In the latter system, the flow rate is governed by the need for renewed air felt by the occupants who can act on the system, or on the level
of airborne contaminants (CO2, water vapor, volatile compounds). Mechanical system are particularly adapted to severe climates and are then often combined with heat recovery (process by which thermal energy is recovered from exhaust air for reuse within the building).

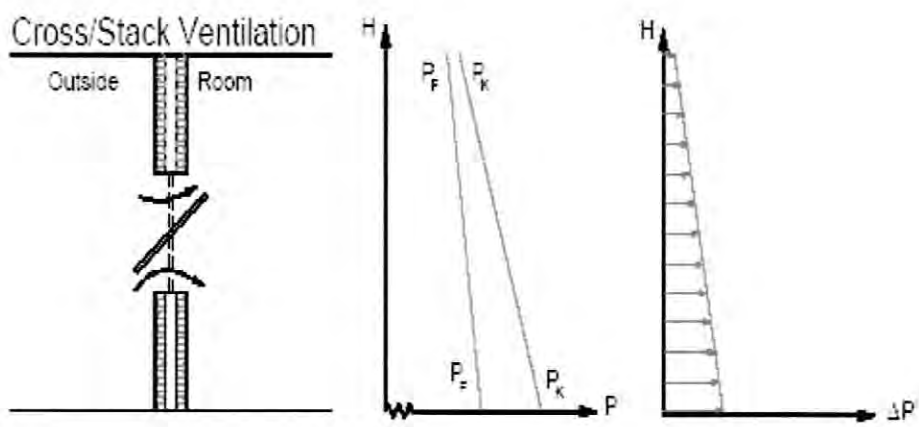
1.2 TYPE OF NATURAL VENTILATION

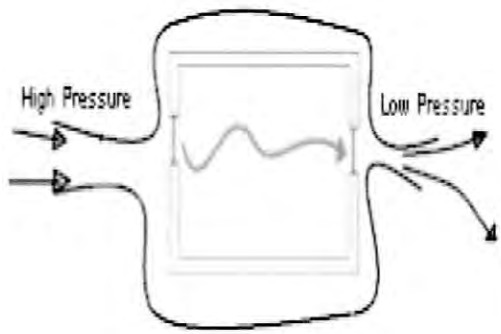
There are two main types of passive ventilation to aid in airflow: cross ventilation and stack ventilation. Cross ventilation techniques use high and low pressure zones created by wind to draw fresh air through a building. Stack ventilation uses high and low pressure zones created by rising heat, causing convection currents. This technique can be implemented by designing an exit vent that draws warm air out of the top of the building and a vent near the lower levels of the building to allow cool air to enter. The air flow through a window depends on the chosen natural ventilation strategy whether chose the cross/stack ventilation or single-sided ventilation. For a cross / stack ventilation strategy the available pressure different across the opening is generally much higher.

For side hung window, the air flow into the room acts as a thermal jet that reaches the floor in a certain distance from the wall dependent on temperature different, pressure different and opening angle. Air movement by the stack effect occurs when the temperature differences between a zone and the environment adjacent to it, be it another zone or the exterior cause the light warm air to rise and flow out the warm zone while cooler airflow will go inside.

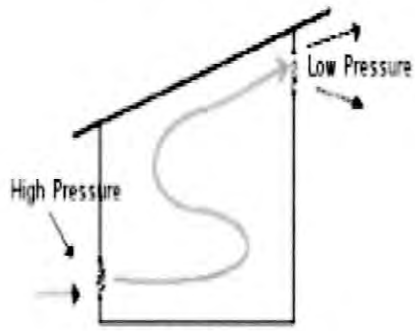
While for a single sided ventilation strategy, the air flow through the hung window is supplied directly to the occupied zone and dependent on temperature difference and window opening area the air reaches the floor from the window. The air flow along the floor can be characterized as stratified flow. Even very small opening angles result in large air flows and high velocity levels in the occupied zone. Single sided ventilation can be achieved by the exchange of air between indoors and outdoors through the opening with the flow of air into a space through one or more inlet and exit openings are at different levels. In general, single – sided ventilation as well as cross ventilation is affected not only by the steady effect of wind pressures and temperatures around and within the building or room, but also by the turbulent nature of wind that causing a diffusion of air through openings. For design purposes, however in single – sided ventilation, stack flow is often considered to be dominant, while the influence of the wind is not so important. Then, the room air flow can be simplified as the consequence of the temperature or density different between the indoor and outdoor environments. A typical situation is the exchange of cool outdoor air with warm indoor air through a single window opening where outdoor air enters the room through the lower part of the opening, while the room air escapes through the upper part.

1.2.1 CROSS / STACK VENTILATION





Cross Ventilation



Stack Ventilation

(Source by Per Heiselberg, Kjeld Svidt, Peter V. Nielsen, 2001. *Characteristic of airflow from open windows.* Aalborg University, Denmark.)

1.3 COMPUTATIONAL FLUID DYNAMICS (CFD)

The Computational Fluid Dynamics (CFD) is a computational technology that enables to study the dynamics of things that flow. By using the CFD, we can built a computational model that represents a system or device that we want to study. Then we can apply the fluid flow physics to this prototype and the software outputs a prediction of the fluid dynamics. CFD is a sophisticated analysis technique. It not only predicts fluid flow behavior but also the transfer of heat, mass (such as in perspiration or dissolution), phase change (such as in freezing or boiling), chemical reaction (such as combustion), mechanical movement (such as an impeller turning) and stress or deformation of related solid structures (such as a mast bending in the wind). CFD provides a cost of effective method to predict the whole flow field in the buildings. Some CFD simulation, in this aspect present promising results and capture the main flow features of phenomena studied. The use of the CFD method to simulate air movement in the building has contributed to understanding of flow features in building.

1.4 TYPE OF WINDOWS

There are two types of windows: those that open and those that don't–called *operable* and *fixed*, respectively. Use as many fixed windows as codes allow, keeping in mind that floors with bedrooms need at least one operable window for emergency exit. Fixed windows are more efficient because of their better air tightness characteristics. They also offer the most safety and security.

Of the operable units, there are many forms: awning, panel, casement, hopper, horizontal slider, vertical slider (either single- or double-hung) and turn-and-tilt. Double-hung windows feature top and bottom windows that slide up and down to open and close. Casement windows swing out on hinges mounted at the top and bottom. Casements are easy to operate and offer an excellent weatherseal. Fixed-sash windows don't open. This can be a blessing, since they remain well sealed and cost far less than operable windows. They can be stacked and ganged with others to create larger units or architectural patterns. Sliding windows are typically the least expensive operable window style. Horizontal sliders have either one or two movable vinyl or metal sashes in a fixed track.

Figure 1.1: Panel window

Figure 1.2: Double side hung window

Figure 1.3: Sliding window

Figure 1.4: Sliding window with bottom hung window at the top

1.5 PROBLEM STATEMENT

Nowadays, there are many type of windows design in the market but the users doesn't know which one is more efficient to use to get more ventilation capacity due to natural ventilation system. Without the suitable window design, it can make the internal temperature rise and will have poor air circulation inside the room during the daytime. Most of the researches and journal about ventilation through openings are in summer and winter season that are totally different with our climate (equator and tropical). Subject to this researches and journal, the end result is not suitable to use and apply in our country. So, by doing this project, the users can use the end result as a guideline to choose the most suitable window design for their room (modern and village house). This research also is to identify perceived barriers restricting the implementation of natural ventilation systems in the window design where its can give good natural ventilation and also would have been sufficient to obtain comfortable indoor climate and good air quality.

1.7 OBJECTIVE

Objectives that have to be achieved at the end of this project are:

a. To create CFD models of various existing windows design.
b. To predict the air flow characteristics via various window configurations and positioning.
c. To propose some fundamental guidelines on the selection of window type base on the required ventilation characteristics and performance.