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THE EVALUATION OF DESIGN GUIDELINES FOR STRATUM VENTILATION IN THE TROPICS

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DECLARATION

I, the undersigned, hereby declare that this report is my own independent work except as specified in the references and acknowledgements. I have not committed plagiarism in the accomplishment of this work, nor have I falsified and/or invented the data in my work. I am aware of the University regulations on Plagiarism. I accept the academic penalties that may be imposed for any violation.

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ABSTRACT

Building ventilation is highly used and rated at one of the highest energy consuming categories. Numerous efforts have been done to reduce energy usage and thus the evolution of green buildings. However, the conventional design has generated plenty comfort and health related issues. Stratum ventilation has been studied from 2009 and the potential of the design for thermal comfort is regarded as good compared to existing designs like the ceiling-based or the under-floor design. INTI International University takes part as study field for simulation model to evaluate stratum ventilation for airflow patterns, velocity profile, temperature, relative humidity and also local mean age. A small room (W4m x L5.15m) and a medium size room (W7.85m x L9.2m) has been modelled and simulated with FloEFD software to understand the stratum potential. Prior to that, the flow of air and velocity of air has been determined using design guidelines and standards that limit the design of stratum ventilation. The overall result of the models is acceptable as the thermal comfort when evaluated using the Fanger's Model of PMV-PPD Model. Occupant's breathing zone is evaluated and PMV Index based on ASHRAE Thermal Comfort Tool has shown majority of the occupants are within the cool region between -0.3 up to -1.3. The local mean age of air for medium size room is ranging from 250s to 300s while small room from 60s to 120s. According to the results, the thermal comfort using stratum ventilation in a tropical country is acceptable.

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DEDICATION

I dedicate this to Mr. Sunny Liew for his endless love and support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ACH	Air Change per Hour
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
CFD	Computational Fluid Dynamics
COP	Coefficient of Performance
DV	Displacement Ventilation
EDT	Effective Draft Temperature
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
LMA	Local Mean Age
MV	Mixing Ventilation
OHAD	Overhead Air Distribution
PMV	Predicted Mean Vote
PPD	Percentage People Dissatisfaction
PV	Personal Ventilation
RH	Relative Humidity
RNG	Re-normalization Group
SV	Stratum Ventilation
TSV	Thermal Sensation Vote
UFAD	Under Floor Air Distribution

NOMENCLATURE

Symbol	*Definition*
A	Surface Area
CLF	Cooling Load Factor
$CLTD$	Cooling Load Temperature Difference
f_{cl}	Clothing Surface Area Factor
h_o	Enthalpy air outdoor
h_r	Enthalpy air in the room
h_c	Convective Heat Transfer Coefficient
I	Intensity Turbulence
I_{cl}	Clothing Insulation
l	Turbulence Length Scale
L	Characteristic Length
M	Metabolic Rate
$\dot{m}$	Fresh Airflow Rate
U	Thermal Transmittance
p_a	Water Vapour Partial Pressure
Q_L	Latent Heat Gain
Q_s	Sensible Heat Gain
Q_v	Ventilation Load
t_a	Air Temperature
t_r	Mean Radiant Temperature
v	Air Velocity
W	External Work

CHAPTER 1
INTRODUCTION

1.1. Background

Since the industrial era, the booming development and urbanization addresses climate change as the most pressing environmental issue. A 1-degree of increase in the average temperature has been recorded over the past two centuries and an exponential projection of possible increase of another 3-degrees globally. Climate change is an irreversible phenomenon. All over the globe, there are places with temperature anomalies causing places to be drier, more extreme and wetter than the previous natural temperature. In the tropics, like Malaysia, is often labeled as hot and humid country. Today, tropical equators are drier and weather fluctuates on a diurnal basis. Occurrence of El Nino has caused extreme events to the Pacific Ocean, bringing rain fall and wind current skewed to the east (Tangang, Hsieh and Tang, 1997). With the increase of heat in the urban areas, buildings and skyscrapers are longing for more cooling environment. The cities are crowded in the extremes of the weather, and air is trapped in the between concrete. As temperature rises, circulation of air eventually drops. The demand for energy continues to soar as the need for cooling air increased.

1.1.1. Building Energy Consumption

Commercial buildings are the third main sector contributing to the high record of 7750 GW per year of energy usage in Malaysia (Yau and Hasbi, 2013). Located in the tropical climate regions, the narrow alleys trapped air movement resulting in high urban thermal plume. Energy efficiency is part of green movement to lower energy usage. Thus, never-ceasing effort has been overwhelming many engineers to achieve a balanced system that is eco-friendly, without compromising the development of the cities. In the past, buildings were strategically designed to promote natural ventilation on elevated height. Exemplary buildings like the Menara PJH in Putrajaya and Platinum Sentral have adapted natural ventilation, in support of the green movement.

TM Tower also had taken a step forward in applying under-floor air conditioning to reduce energy consumption. However, due to climate change, high-rise buildings use forced air ventilation and demand greater cooling loads via air-conditioning system.

Efforts have been done to promote change through better cooling devices, innovative designs of systems and integration and manipulating the operation management and control towards green environment (Chua et al., 2013). Considering all factors, better ventilation encourages better health and simultaneously a more sustainable energy use. Air-conditioning ventilation that is widely used is the overhead ventilation (OHAD) and under floor air distribution (UFAD), that constantly require high-energy consumption to cool air. A discovery of a new ventilation system, stratum ventilation method has been investigated and implemented in the subtropical regions like Hong Kong and China.

1.1.2. Potential Ventilation System

Stratum ventilation is potential in providing good thermal comfort and also very energy efficient. Various simulation scenarios have been studied to demonstrate that the ventilation system is effective in delivering desired results for all types of consumers of sedentary or mobile occupants. The stratum ventilation has proved its feasibility for buildings in subtropical region, where average temperature is 23.3 degree Celsius and mean humidity of 76%. For this study, comparing to tropical country alike Malaysia of average temperature, 28 degree Celsius and relative humidity of 80% on a daily basis as illustrated in Figure 1.1. The stratum ventilation is reinvestigated to validate the feasibility of such design in a hot and humid climate.