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EXPLORING THE INDOOR AIR MOVEMENT CONDITION IN THE STUDENT RESIDENTIAL BUILDING AT POLITEKNIK UNGKU OMAR

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ABSTRACT

Natural ventilation is a crucial and profound aspect in anticipating permissible indoor air movement in built environments. An appropriate ventilation operationalisation in built environments aids in providing fresh air and expels heat and indoor pollution. Hence, the objective of this study is to explore the current indoor air movement condition in the student residential building. A field measurement was executed in a pre-detriment room to analyse current indoor air movement. A model of the case study room similar to the field measurement was developed using computerized simulation software with two (2) sets of opening configurations. Findings showed that the range of air velocity of the case study room in opening configuration (1.0 m/s during midday) did not meet the Malaysian Standard requirement (0.25–0.50 m/s) for a potential natural ventilation strategy as a cooling effect in internal building space. The study concluded that uncomfortable conditions in the case study room and recommendations for improvements to the future development of Malaysian Polytechnics might help to provide better indoor air movement conditions.

1. Introduction

Climate change is a major issue that affect all mankind around the world nowadays and will most likely affect the future generations. As climate changes, buildings built to run under former climatic conditions will not perform well under current conditions impacting the wellbeing of those who live, work, study or play. One of the consequences of this problem is an increase in global air temperature, which causes discomfort in indoor thermal environment. The Institute of Medicine (IOM, 2011) summarized the current state of scientific understanding of the effects of climate change on indoor air and public health and concluded that climate change influences indoor environmental quality, warranting attention and action. This conclusion is based on three main findings: poor indoor environmental quality causes health problems and impairs occupants' ability to function and learn, climate change may worsen existing indoor environmental problems which add new problems and potential to enhance public health while mitigating or adapting to indoor environmental quality changes are available (Rana et al.,2017).

Due to the increase of awareness of discomfort in indoor environment, numerous studies on various types of building such as residential, commercial, and education buildings has been taken by researchers worldwide in facing the discomfort issue in buildings Sadrizadeh et al., (2022) reviewed several recent and notable studies and highlighted that the implications of climate change on indoor air quality (IAQ) are numerous and complex. Among the effects of climate change on factors that govern IAQ were properties of pollutants, building factors, occupant behavior as well as outdoor and indoor environment conditions. According Xu et al., (2021) climate change is widely predicted to raise air pollution concentrations in the future, with several research projecting higher relative changes in PM2.5, the main pollutant adding to the health burden of air pollution. In addition, as stated by Wang et al., (2019) the indoor thermal environment should be designed to maintain maximum human productivity and performance. Therefore, buildings should provide high quality, comfortable environments to support the activities of their occupants. The main purpose of buildings is to provide a comfortable living environment for their occupants. The indoor environment of buildings especially residential has a significant impact on health and quality of life (Baeza_Romero et al., 2022). High quality environments result from appropriately combining a variety of building systems, and the performance of those systems must be compatible with the activities of the occupants. From the occupant perspective, the ideal indoor environment is one that satisfies all occupants without unnecessarily increasing the risk or severity of illness or injury (Wierzbicka et al., 2018).

According to Green Building Index Malaysia (GBI), indoor environment quality (IEQ) can be achieved through good quality performance in indoor air quality, acoustics, visual and thermal comfort (Saadoon Abdulaali et al., 2020). These will involve the use of low volatile organic compound materials, application of quality air filtration, proper control of air temperature, movement and humidity. Based on this achievement, IEQ will contribute to a conducive environment to human health and productivity. Hence, occupants will be more satisfied on the thermal comfort, air quality and overall living space. According to Mokhtariyan Sorkhan et al., (2024) the relationship between indoor environmental quality (IEQ) and occupant satisfaction has become a vital field of study in the design and construction process. The significance of the relationship is emphasised as IEQ has a direct impact on changing people's behavior due to its design, especially in places such as an office building.

A critical analysis of the literature revealed that IEQ parameters such as thermal, noise, illumination, and air quality may have a significant impact on human comfort and health while also playing an important role in energy use in the building. The comfort of building occupants is dependent on many environmental parameters including air speed, temperature, relative humidity, lighting and noise. Diaz et al., (2021) described IEQ as an indication of the degree of comfort that is not limited to thermal conditions and includes elements such as thermal comfort, acoustic comfort, indoor air quality, and visual comfort. Hence, this study provides insight into the exploration on the current indoor air movement condition in the student residential building at Politeknik Ungku Omar.

2. Methodology

In achieving the objectives of the research, this research was conducted in two main stages. Stage 1 is the data collection stage where field measurement on selected room in case study building is performed to gather data on current living environment. Stage 2 will be the simulation test models experiment using computer software. These models will be developed to conduct experiments with different opening configurations to identify indoor air movement patterns including existing room layout. Findings of works to all two stages will be analysed and discussed based on Malaysian Standard, MS2680 (2017) Energy Efficiency and Use of Renewable Energy For Residential Buildings – Code of Practice.

Figure 1 shows the overview of Politeknik Ungku Omar indicating the location of the student residential building where field measurement for data collection is performed. This complex was built on Northwest- Southeast (Block A and B) and Northeast-Southwest orientation (Block C, D and E) consists of 5 blocks. It has two double loaded layout with centralized corridor with 5 each floor level in each block has 16 rooms designed to accommodate up to 6 students. Rooms are divided by a 2100mm high brick wall to provide individual private space for each individual with side hinged casement window with overlapped glass panel top hung. The typical dimension of the room is 5.4 meter x 7.5 meter x 3.3 meter high as shown in Figure 2. The layout of the room which divided into six individual private spaces using 2100mm high brick partition as shown in figure 3. Rooms are naturally ventilated using single-sided casement windows whose opening angles are 30 degrees, which are limited for security purposes as shown in figure 4., 3 ceiling fans are provided to help cooling the room by circulating the air in the room.

Figure 1. The overview of the new residential building in Politeknik Ungku Omar Ipoh (Source: www.google.com/maps)

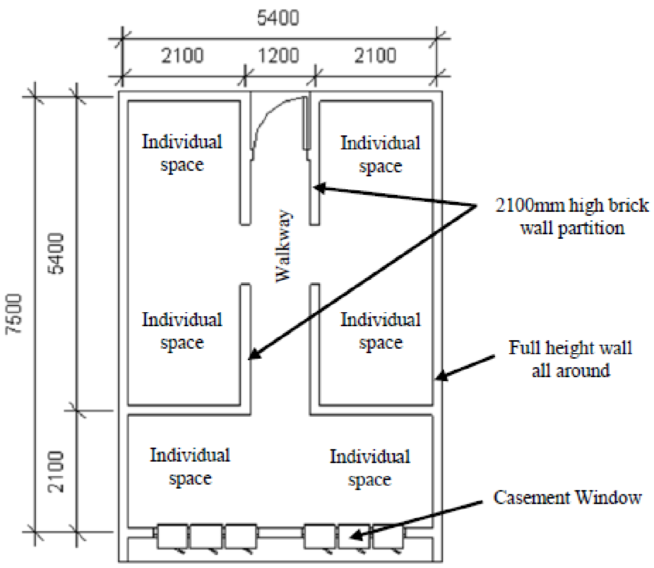

Figure 2. Dimensions of typical room in new student residential building

Figure 3. 2100mm high brick wall to give individual private spaces for each student

Figure 4. The individual spaces for student next to the main window

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The field measurement was conducted in selected room in the case study building determined by computational simulation of the entire site consists of 5 residential buildings during preliminary assessment. Block D was chosen for the case study building as it received the least wind flow based on the simulation. VelociCalc Velocity Meter which was the instrument used to measure the indoor environment parameter in the case study room. It can measure and log data using a single probe with multiple sensors that measure air velocity, temperature and relative humidity. For air velocity, it has the capability to measure a range between 0 to 4000 ft/m (0 to 20 m/s). The logging interval could be set up from 1 second to 1 hour. During the measurement process in collecting the indoor environmental parameter, the VelociCalc Velocity Meter was placed in the centre of Individual Space 3 (Figure 5) next to windows in which data of incoming air velocity can be logged sufficiently. Sensor probe was set and placed free from any obstruction on a table 1.2 meter high from floor level which is the typical human body and located 1.2 meter from wall in 90° angle vertical position. Data for air velocity collected for 24 hours for six days and were logged every 15 minutes. The windows are left opened throughout the period of measurement and ceiling fans were switched off during the measurement time.

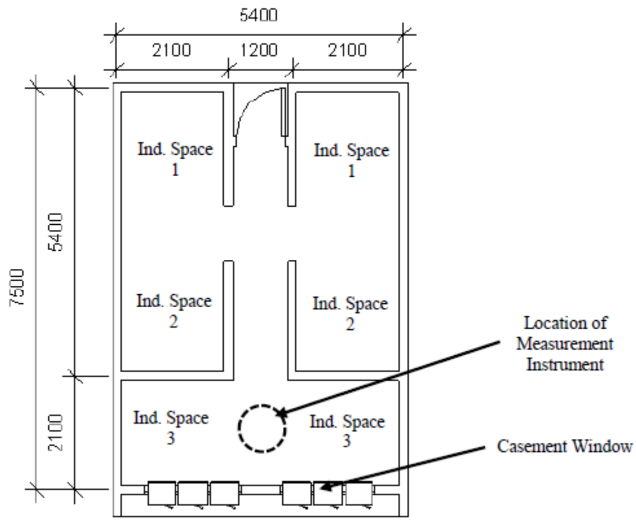

Figure 5. Ground floor plan of Block D indicating the selected room location and the location of measurement instrument in the selected room

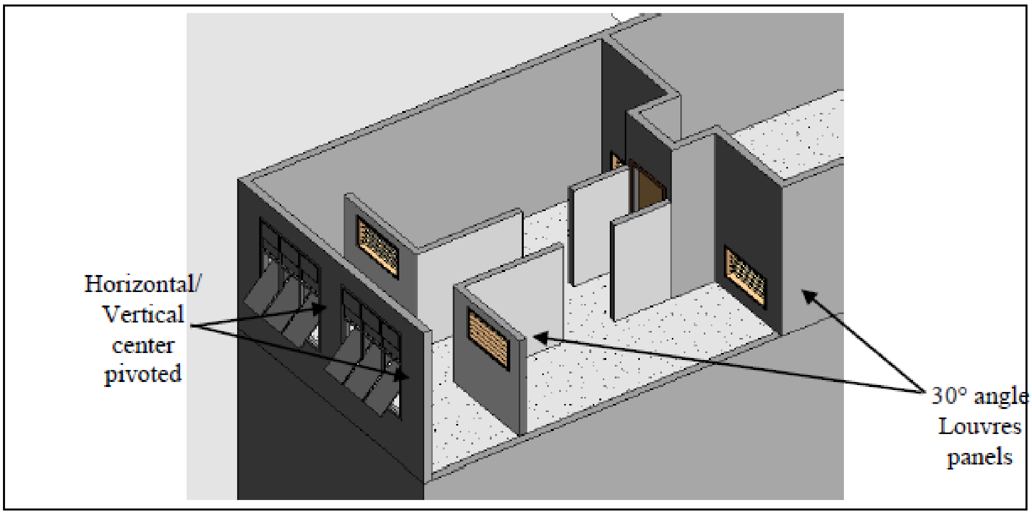

Figure 6. Example of test model with opening configuration set 1

For opening configurations set 2, simulations were done on eight test models (TM)simulations were done on eight test models (TM). The window openings at windward wall were vertical and horizontal center pivoted window panels. The 2.1 meter high internal partitions and corridor wall were set with 15° angle slat louvres panel at various height. Figure 7 represent the example of test model with opening configuration set 2.

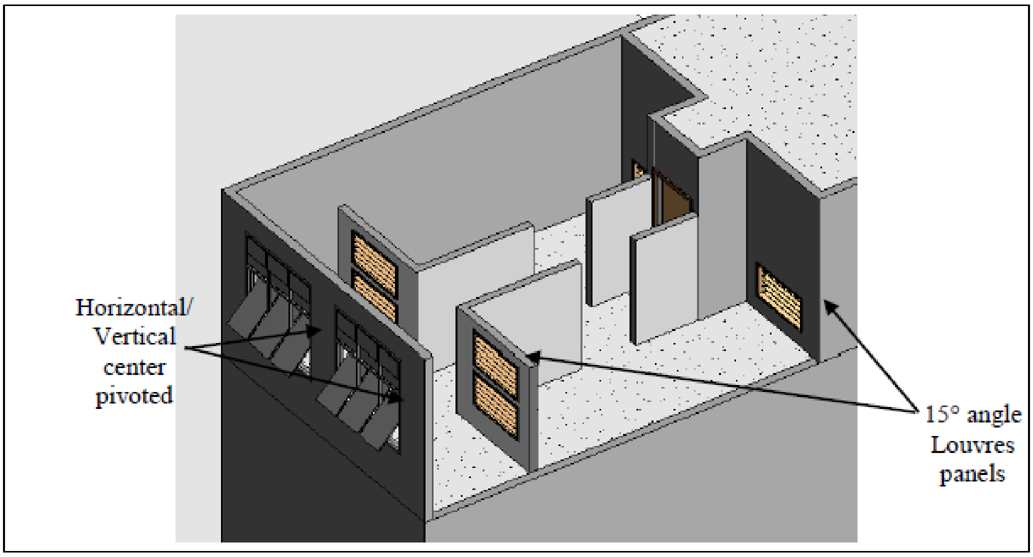

Figure 7. Example of test model with opening configuration set 2

3. Results

Figure 8 shows the graph of the average hourly indoor air velocity for six days of the field measurement. During the measuring period, the indoor air movement shown a similar trend for all six days where high velocity recorded in the early afternoon until early evening from 11.01

am to 17.01 p.m. with the average air velocity of 0.03 m/s. The highest indoor air velocity was recorded on Day 6 at 13.16 pm which was 1.0 m/s. During this period, the average air velocity was between 0.00 m/s to 0.02 m/s only which indicated no air movement in the case study room. The summary findings are displayed in Table 1.

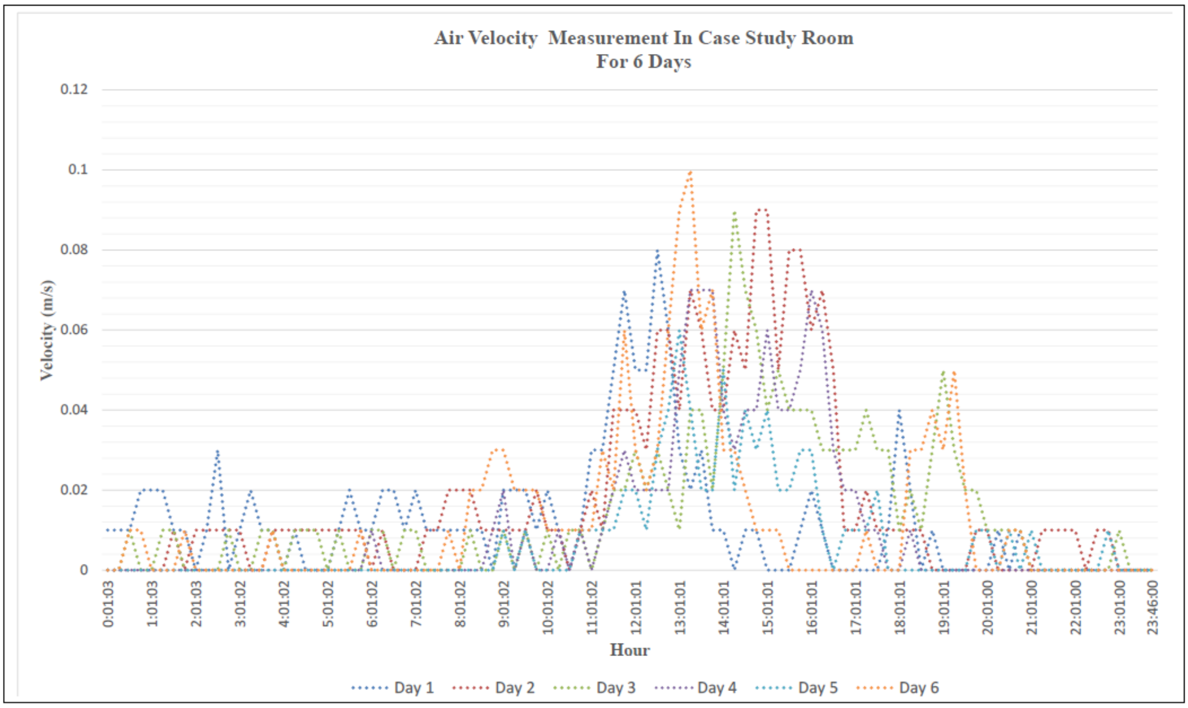

Figure 8. Air Velocity Measurements in Case Study Room Recorded in 6 Days

Table 1. Summary of data collection consist of air velocity

Parameter	Air Velocity (m/s) Indoor
Minimum:	0
Time of Minimum:	19:16:01
Date of Minimum:	18/5/2018
Maximum:	0.1
Time of Maximum:	13:15:47
Date of Maximum:	23/5/2018
Average:	**0.01**

Table 2 provides a guide on the impact of air speed on occupants' sensation according to Malaysian Standard, MS2680 (2017) Energy Efficiency and Use of Renewable Energy for Residential Buildings – Code of Practice. Although there were signs of air movement in the case study room during the six days of field measurement period, it was found that the range of indoor air velocity did not meet the standard requirement by MS2680:2017 which led to a

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discomfort condition of occupant. Air velocity or air movement is critical for human comfort as it increases the heat transfer between the atmosphere and the human body and thus speeds up the body's cooling process. Air velocity or air movement tends to moderate indoor air temperature, providing occupants with thermal comfort. Higher air velocity and more varied direction of the air offer a higher impact to the indoor environment. The recommended air velocity is 0.25 m/s – 0.50 m/s where occupant would feel fresh at comfortable temperature.

Table 2. Impact of Air Speed on Occupants'' Sensation

Air speed (m/s)	Mechanical effect	Occupant sensation
≤ 0.25	Smoke (from cigarette) indicates movement	Unnoticed, except at low air temperatures.
0.25 - 0.5	Flame from a candle flickers	Feels fresh at comfortable temperatures, but draughty at cool temperatures.
0.5 - 1.0	Loose papers may be moved. Equivalent to walking speed	Generally pleasant when comfortable or warm, but causing constant awareness of air movement.
1.0 - 1.5	Too fast for deskwork with loose papers	Acceptable in warm conditions but can be from slightly to uncomfortably draughty.
> 1.5	Equivalent to a fast walking speed	Acceptable only in very hot and humid conditions when no other relief is available. Requires corrective measures if comfort and productivity are to be maintained.

Adapted from: MS 2680:2017

Figure 9 represents the plotted graph for the average indoor air velocity for all test models in opening configuration set 1. It shows similar trend whereby all graphs decreased evenly from individual space 3 to individual space 1. It is observed that air velocity entering through the opening at windward facade decreased as it moved in individual space 3 and did not penetrate the louvre panels at internal partition towards individual space 2 and individual space 1. There was no sign of air moving through the louvres at internal partition resulting the air velocity at individual space 2 and 1 are seen to be very low and stagnant. It was found that the average result of the air velocity for these test models did not meet the standard requirement by the Malaysian Standard MS2680:2017. The summary reading of simulation for Opening Configuration Set 1 are displayed in Table 3.

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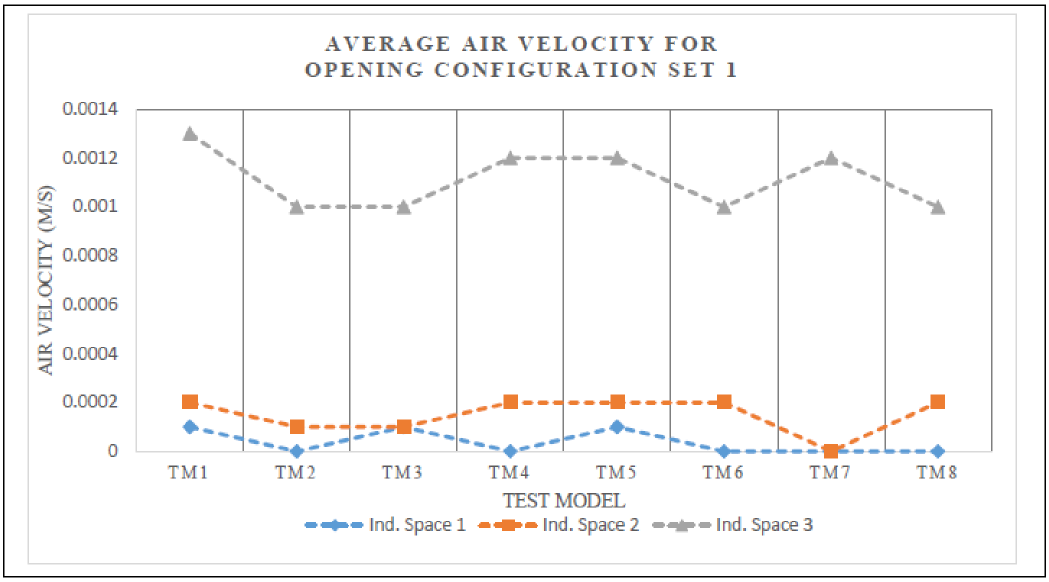

Figure 9. Average Air Velocity for Opening Configuration Set 1

Table 3. Summary reading of simulation for Opening Configuration Set 1

TEST MODEL	Air Velocity at Ind. Space 1 (m/s)	Air Velocity at Ind. Space 2 (m/s)	Air Velocity at Ind. Space 3 (m/s)
TM1	0.0001	0.0002	0.0013
TM2	0.00	0.0001	0.0001
TM3	0.0001	0.0001	0.0001
TM4	0.00	0.0002	0.0012
TM5	0.0001	0.0002	0.0012
TM6	0.00	0.0002	0.0001
TM7	0.00	0.00	0.0012
TM8	0.00	0.0002	0.0001
Average Air Velocity(m/s)	0.00	0.0001	0.0012

Figure 10 represents the plotted graph for the average indoor air velocity for all test models in opening configuration set 2. It shows similar trend whereby all graphs decreased evenly from individual space 3 to individual space 1 causing the reading in individual space 1 and 2 to be lower than individual space 3. It is observed that high air velocity entering through the opening at windward facade decreased as it moved in individual space 3 and did not penetrate the louvre panels at internal partition towards individual space 2 and individual space 1 although additional 2 set of louvres panel are suggested as a solution to improve air movement.

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It was found that the average result of the air velocity for these test models did not meet the standard requirement by the Malaysian Standard MS2680:2017 which between 0.25 m/s and 5.0 m/s. The summary reading of simulation for Opening Configuration Set 2 are displayed in Table 4.

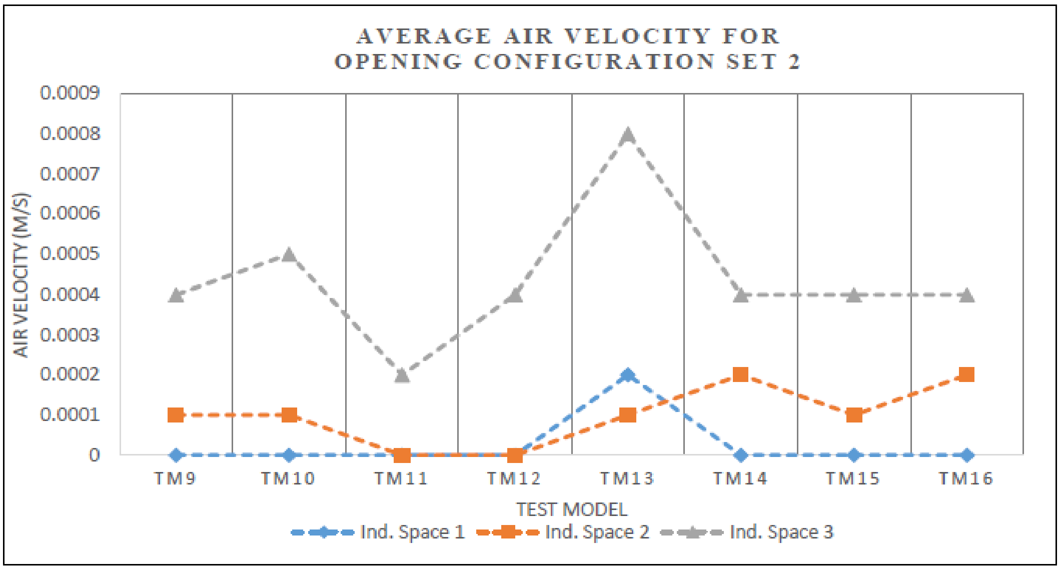

Figure 10. Average Air Velocity for Opening Configuration Set 2

Table 4. Summary reading of simulation for Opening Configuration Set 2

TEST MODEL	Air Velocity at Ind. Space 1 (m/s)	Air Velocity at Ind. Space 2 (m/s)	Air Velocity at Ind. Space 3 (m/s)
TM9	0.00	0.0001	0.0004
TM10	0.00	0.0001	0.0005
TM11	0.00	0.00	0.0002
TM12	0.00	0.00	0.0004
TM13	0.0002	0.0001	0.0009
TM14	0.00	0.0002	0.0004
TM15	0.00	0.0001	0.0004
TM16	0.00	0.0002	0.0004
Average Air Velocity(m/s)	0.00	0.0001	0.0004

4. Discussion

The findings of this study reveal critical insights into the indoor air movement conditions within the student residential building at Politeknik Ungku Omar. The measured air velocities, averaging 0.01 m/s and peaking at 1.0 m/s during midday, fell significantly below the Malaysian Standard MS2680:2017 requirement of 0.25–0.50 m/s. This inadequacy underscores a systemic issue in the building's passive ventilation design, which fails to align with occupant needs and climatic adaptability. The implications of these results are multifaceted, touching on health, comfort, and energy efficiency, and warrant a thorough discussion in the context of existing literature and building design practices.

First, the low air velocity during occupancy hours (evening to morning) directly compromises thermal comfort and indoor air quality (IAQ). As noted by Diaz et al. (2021), IEQ parameters such as air velocity and temperature are critical to occupant well-being. The near-stagnant air (0.00–0.02 m/s) during these periods creates a microenvironment conducive to heat retention and pollutant accumulation, exacerbating discomfort and potential health risks. This aligns with Sadrizadeh et al. (2022), who emphasized that inadequate ventilation in educational buildings can impair cognitive performance and health, particularly in tropical climates where humidity exacerbates thermal stress. The temporal mismatch between peak airflow (midday) and occupancy (evening) further highlights a design flaw, as natural ventilation strategies must prioritize occupant activity patterns to be effective (Wang et al., 2019).
The building's architectural configuration appears to be a primary contributor to the poor airflow. The single-sided casement windows, limited to a 30° opening angle for security, restrict cross-ventilation—a cornerstone of passive cooling in tropical regions. Cross-ventilation relies on pressure differentials between building facades, which are hindered by the absence of opposing openings (Mokhtariyan Sorkhan et al., 2024). Additionally, the 2100mm high partitions subdividing the room into individual spaces likely disrupt airflow pathways, creating stagnant zones. These design choices contradict the Green Building Index Malaysia (GBI) guidelines, which advocate for unobstructed airflow and strategic opening placements to enhance IEQ.

The study's use of CFD simulations to validate field measurements strengthens the reliability of the findings. While the paper does not elaborate on simulation specifics, the congruence between empirical data and modeled scenarios suggests that computational tools can effectively diagnose ventilation inefficiencies. However, the persistence of low airflow even in simulated "optimal" configurations implies deeper systemic issues, such as site orientation or surrounding wind obstructions. Block D's selection as the least ventilated block underscores the impact of urban layout on microclimate, a factor often overlooked in building-scale analyses (Xu et al., 2021).

To address these challenges, several interventions are proposed. Redesigning window systems to allow larger openings—such as louvers or adjustable vents—could enhance airflow without compromising security. Introducing cross-ventilation via strategically placed openings on opposite walls would leverage pressure differentials, as recommended by MS2680:2017. Hybrid ventilation systems, combining natural airflow with energy-efficient mechanical fans during low-wind periods, could also bridge the gap between design intent and occupant needs.

Furthermore, lowering partition heights or incorporating perforated materials might mitigate airflow disruption while preserving privacy.

The study's limitations, including its focus on a single building and short measurement period, invite caution in generalizing results. Seasonal variations, occupant behavior (e.g., window adjustments), and regional wind patterns could influence airflow dynamics. Future research should expand to multiple buildings, incorporate longitudinal data, and explore occupant interactions with ventilation systems. Such efforts would align with global calls for climate-resilient building designs that prioritize adaptive strategies (Sadrizadeh et al., 2022).

In conclusion, this study underscores the urgent need to reevaluate ventilation design in Malaysian Polytechnics' residential buildings. By integrating passive design principles, responsive to both climatic and occupant needs, future developments can achieve compliance with IEQ standards while fostering healthier, more productive living environments. These improvements not only align with Malaysia's sustainability goals but also contribute to global efforts in mitigating climate change impacts on built environments.

5. Conclusion

This study investigated the indoor air movement conditions in student residential buildings at Politeknik Ungku Omar, focusing on compliance with the Malaysian Standard MS2680:2017. Field measurements and computational simulations revealed that the average air velocity (0.01 m/s) fell significantly below the recommended range of 0.25–0.50 m/s, particularly during evening occupancy hours. The low airflow, exacerbated by design limitations such as single-sided casement windows (restricted to 30° openings) and 2100mm high partitions, hindered cross-ventilation and created stagnant zones. These conditions compromise thermal comfort and indoor air quality, aligning with broader findings that inadequate IEQ adversely impact occupant health, productivity, and well-being in tropical climates.

To address these issues, strategic interventions are proposed, including redesigning window systems for larger openings, incorporating cross-ventilation pathways, and modifying partitions to balance airflow and privacy. Hybrid ventilation systems combining natural airflow with energy-efficient mechanical solutions could mitigate low-wind periods. While the study's focus on a single building limits generalizability, the findings underscore the urgency of aligning architectural designs with climatic and occupant needs. Future research should expand to multiple buildings, incorporate seasonal data, and evaluate occupant behavior to develop adaptive, climate-resilient strategies. Adherence to IEQ standards is essential for advancing Malaysia's sustainability goals and ensuring healthier, more productive living environments in educational institutions.

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