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SUSTAINABLE BUILT ENVIRONMENT

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ENHANCING INDOOR AIR QUALITY THROUGH EFFECTIVE VENTILATION

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ABSTRACT

This article investigated the effective ventilation to enhance the better indoor air quality into a residential building in Malaysia. A periodic field measurement have been set up in order to collect all the available parameter that would distribute for data collection process such as relative humidity, temperature and carbon dioxide within a house. Two residential building with different type of building ventilation (opening) located in Rantau Panjang, Kelantan have been choose as the sample for this study so that a brief comparison on recorded indoor air quality rate can be made and analyse . The data gathering process be made via Indoor Air Quality Monitoring Instrument which left on each case study both for 2 days. The study focused and identified the proper building ventilation in order to improve the quality of air within a building. Through the study, the indoor air quality in a building can be maximise. These findings also can point out best practises, educate construction regulations, and advise homeowners, designers, and decision-makers on how to make single-story residential structures' interiors healthier and more pleasant.

Keywords: *Ventilation, Indoor air quality, single storey residential building, opening.*

INTRODUCTION

Ventilation in buildings is crucial for providing healthy and fresh air for occupants, replacing stale air with fresh air. It dilutes pollutants originating within the building and removes them (Atkinson, 2009). There are three basic elements for building ventilation: ventilation rate, airflow direction, and airflow distribution. The rate depends on the amount of outdoor air provided into the designated space, while the airflow direction includes the overall airflow direction inside a building and flows from clean zones to dirty zones. The air distribution pattern ensures efficient delivery of external air to every part of the building. Indoor Air Quality (IAQ) and ventilation are inextricably linked in building design and operation. Effective ventilation systems play a critical role in improving IAQ by continually exchanging stale indoor air with fresh outdoor air, diluting and eliminating interior pollutants released by occupants and other sources.

In other words, poor indoor air quality is primarily caused by pollution from sources emitting gases or particles into the air. Insufficient airflow can increase indoor pollutant levels, and high humidity levels and temperatures can also contribute to pollution concentrations. Poor ventilation can lead to mold growth, condensation, low oxygen levels, and airborne contaminants, resulting in both short-term and long-term health implications for building occupants (Luna, 2021). Indoor Air Quality (IAQ) is the quality of the air within and around a building, affecting occupant comfort and health. Proper understanding of common pollutant control is essential for indoor health. Building design and orientation also play a significant role in maintaining indoor temperature.

LITERATURE REVIEW

The building ventilation be mentioned as a need for a building owners many centuries before but it is only evolved on early 1970s both for building and transport's system. There are various numbers of researchers stated that the ventilation is needed in a building's requirement in order to provide comfort and good indoor air quality for their occupants (Awbi, 2015).

The ventilation do have a broad history that be developed through the changes that be brought by the building and industries' evolution along with our personal needs. The ventilation and air quality are known for its obvious connection. So, it is not surprising that the ventilation and health been linked together and related with each other. The word 'ventilation' comes from the Latin ventilatio where in turn from ventus which means wind. In 1660, this process be described as action to replace the poor air within a confine space with a clean and new air. Moreover, it is also be used on to mean 'breathing' that exchange the oxygen and carbon dioxide in our lungs which describe the process of liberating and cleansing (Swegon Air Academy, 2013).

The ventilation known as the exchange or circulation of air inside a place in order to preserve indoor air quality. It includes the flow of air into and out of a structure or a specific location inside one. Based on U.S. Department of Energy, the ventilation function as an energy efficient for a home. With a proper amount and type of ventilation that be choose able to cool down the house. As we know, each house do have different occupancy levels which are the people and pets, their activities within the house, health concerns and etc. In addition, chances of mold growth and structural damage can be reduce with an excellent ventilation as it able to control the moisture within a building. In order to cool down a building, ventilation for cooling are known to be least expensive and most energy-efficient. A ventilation that be combined with a proper technique able to prevent the heat build-up within a property. In addition, the building design also determine the ventilation airflow for the building where it is able to promote the occupants health whenever they enter the occupied space.

Determination of IAQ and Its Issues

Indoor Air Quality (IAQ) known as the quality of air inside or at the surrounding of the buildings which commonly related to the occupants health and comfort. In order to reduce the indoor health risk, understanding and controlling the common pollutants within a building is a must. Indoor air quality is very important and become the major concern for the home's owners as it can impact their health, productivity, comfort and well-being. Improper environment of indoor air quality can expose the users to an increasing risk of illness where several independent scientific panel have persistently identified indoor air pollution as a significant environmental health issue. While most buildings do not have severe indoor air quality issues, even well-run buildings can occasionally experience poor indoor air quality episodes. Based on a 1989 EPA Report to Congress, it is summarise that the excellent indoor air quality able to boost the productivity and fewer lost work days (EPA, 2022). A residential building is one that contains separate residences where people can live or stay on a regular basis. Each residence has its own kitchen and bathroom and may also be referred to as an apartment or a condominium.

Figure 1: Factors of Poor IAQ (Ravindra & Mor, 2022)

Based on Webster's Third New International Dictionary (1993), a residence is defined as "a temporary or permanent dwelling place, abode, or habitation to which one intends to return, as opposed to a temporary sojourn or transient visit." According to Dr. Amir Hamzah Abdul Latiff, President of the Allergies and Immunology Association Malaysia, 30-40% of Malaysians suffer from sinusitis allergy due to poor indoor air quality. Indoor air quality, which is frequently related with Sick Building Syndrome, has lately become a concern for building inhabitants all over the world. High relative humidity and unmanaged temperature in a structure can promote bacterial and fungal development, which can lead to allergies, respiratory health effects, and asthma among its residents. First and foremost, it is critical to conduct an examination and assess the quality of indoor air, especially if you or the facility you occupy are suffering the symptoms listed above. Temperature, humidity, carbon monoxide, carbon dioxide, dust, total volatile organic compound, air movement, formaldehyde, bacterial and fungal count will be analysed and quantified using specific instruments. Poor ventilation, floor cleaning, garbage build up, carpeting, fresh air intake point, large number of inhabitants, pest control operations, and remodelling are all elements that contribute to indoor air pollution.

RESEARCH METHODOLOGY

This study employed a quantitative approach by installing an Indoor Air Quality Monitoring Instrument near an opening in the kitchen at a height of about 1 metre from the floor. The IAQ instrument are set up in each case study for two days to monitor the changes in parameters that will be compared afterwards. Nevertheless, in this study, we only analyzed data from 7:00 in the morning until 7:00 in the evening. Both case studies will have an hourly interval time of 15 minutes. Due to a technical glitch, researcher were only able to conduct the measurement over a two-day period instead of the intended three. Periodic checks of the case studied area have been performed all through the measurement process to ensure the instrument is functioning properly. The Indoor Air Quality Monitoring Instrument and a measuring tape were utilised in this study. The measuring tape were utilised to remeasure the building to help with the plan making process. Using the P37AB147 probe, the IAQ device measures airspeed, relative humidity, temperature, ambient pressure, carbon dioxide, and carbon monoxide as shown in Figure 2. However, during the measurement process, the relative humidity (%), CO2 (ppm), and temperature (°C) of both case studies were focused on.

Figure 2: Indoor Air Quality Monitoring Instrument

CASE STUDY

On sunny season between June-July of 2023, two bungalow houses has been choose through snowball technique as the case study for this research. For medium-sized residences in Malaysia, both case studies show modern and contemporary approaches to architecture and landscaping. Both case studies are located at Kampung Bendang Ikan, Rantau Panjang, Kelantan as shown in Figure 3 and 4. Details description of the case study are tabulated in Table 1.

Figure 3: Case Study 1

Figure 4: Case Study 2

Table 1: Case Studies Description

Coordinate	5°55'54.8"N 102°03'33.9"E	5°55'42.3"N 102°03'33.4"E
Occupancy	3	5
Building Area	126 468.9m^2	153 547.7m^2
Opening Types	CASEMENT	LOUVER

DATA COLLECTION AND ANALYSIS

The following graphs provide a summary of the data that was collected over the course of two days as part of an investigation into the impact of various types of openings acting as ventilation mechanisms in residential houses on the quality of the air within the homes.

Based on graph shown in Figure 5, for the CS 1, the RH readings shows the inconsistent pattern where the highest data be recorded at 99.2 % at 9:32:58 a.m., while the lowest at 82.9 % at 4:32:58 p.m. and the average at 90.3 %. For carbon dioxide the highest data be recorded on 8:17:58 am at 833 ppm while the lowest at 467 ppm at 11:47:58 a.m. and the average at 552 ppm. Then, the highest data for temperature be recorded at 31.25 °C at 4:32:58 p.m. and hold till 5:17:58 p.m. , while the lowest at 27.75 °C at 7:32:58 a.m. and the average at 29.69 °C.

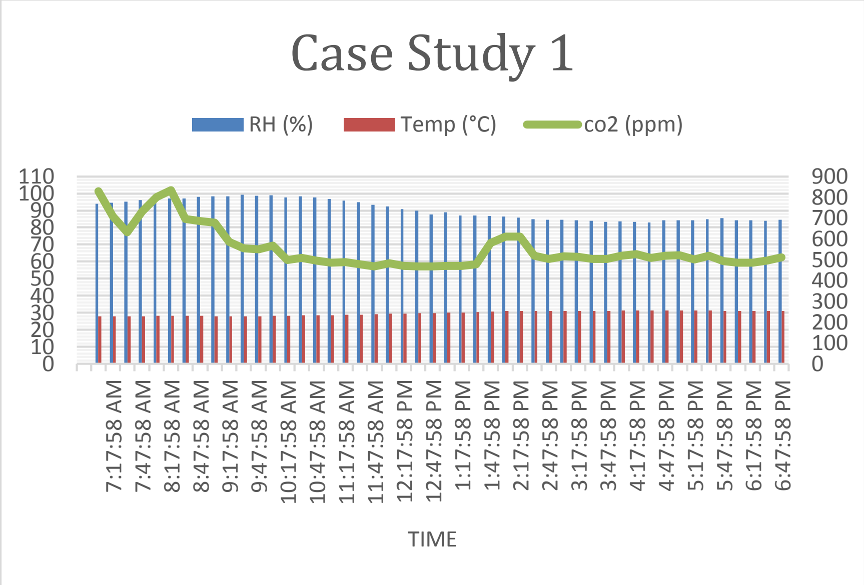

Figure 5 : Analysis of Parameters Measured of CS1

Meanwhile, for the CS 2 (Figure 6), the RH readings also shows the inconsistent pattern where the highest data be recorded at 93.4 % at 8:32:58 a.m., while the lowest at 65 % at 2:47:58 p.m. and the average at 78.1 %. For carbon dioxide the highest data be recorded at 709 ppm at 7:02:58 am while the lowest at 438 ppm at 1:47:58 p.m. and the average at 503 ppm. Then, the highest data for temperature be recorded at 33 °C at 2:32:58 p.m. and 3:17:58 p.m., while the lowest at 27.5 °C at 8:05:58 a.m. and hold till 8:32:58 a.m. and the average at 30.7 °C.

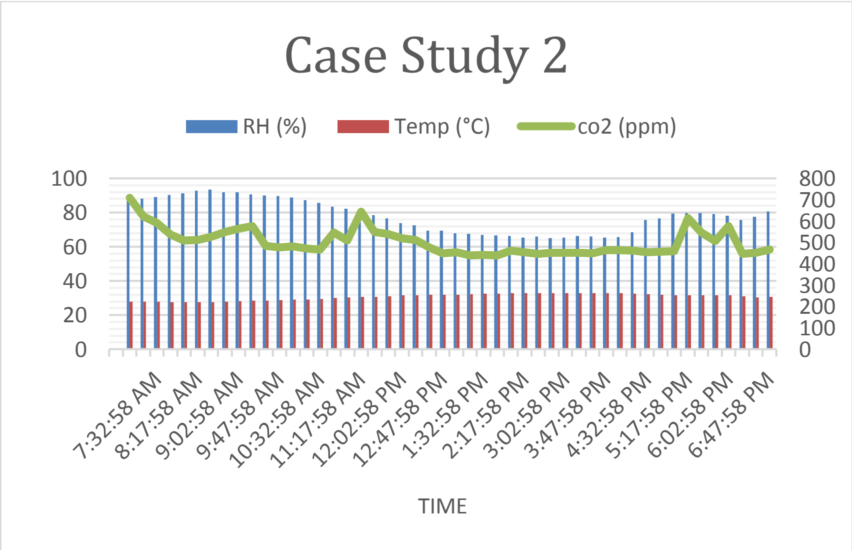

Figure 6 : Analysis of Parameters Measured of CS2

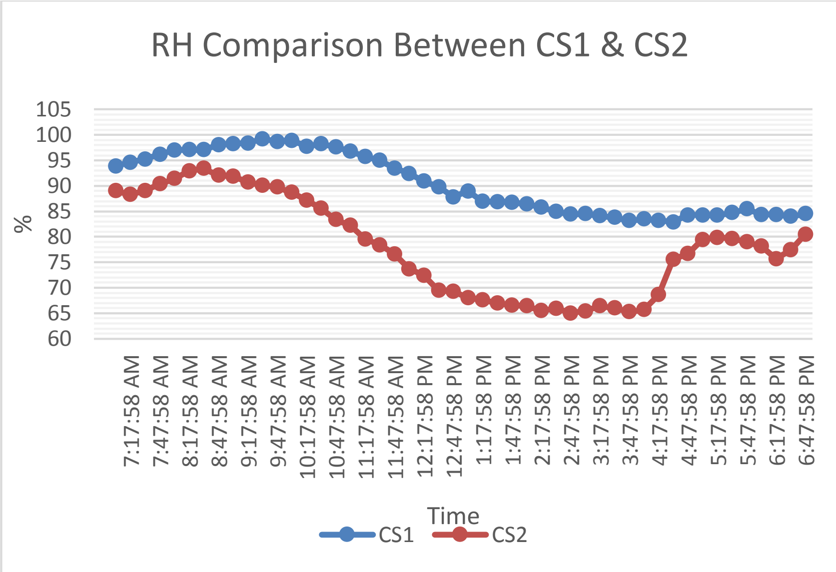

Figure 7: RH Comparison between CS1 & CS2

According to the graph as shown in Figure 7, CS1 and CS2 both experience daily changes in their levels. However, there are variances between the two in terms of the general tendency. CS1 typically rises in the morning and falls throughout the course of the day, whereas CS2 exhibits greater variance without a distinct trend. Additionally, CS1's value range is broader than CS2's. While CS2's range is 65.5 % to 93.4 %, CS1's is 82.9 % to 99.2 %. This suggests that CS1 experiences more humidity changes than CS2 does. Additionally, CS1 often displays greater numbers throughout the day than CS2 does. Furthermore, CS1 has more peaks and valleys and variability than CS2, which seems to have a more constant range of values. However, CS1 and CS2 both exhibit a pattern where greater values are reached in the morning and lower values are reached in the afternoon and evening. This demonstrates that the two variables could be correlated.

Meanwhile, analysis on Co2 level of CS1 and CS2 both exhibit daily variations in their values as shown in Figure 8. However, CS1 typically displays larger values than CS2, suggesting that the underlying causes impacting the two variables may be different.CS1's value range is larger than CS2's. CS1 spans the numbers 468 ppm to 833 ppm, whereas CS2 spans the numbers 439 ppm to 709 ppm. This shows that CS1 experiences more value changes than CS2 does. CS1 often displays greater numbers throughout the day than CS2 at most times. Consistent differences between the two variables suggest that the fundamental causes of CS1 and CS2 may differ. However, both CS1 and CS2 show daily value swings, with some comparable peaks and troughs. The size of these variations varies between the two variables.

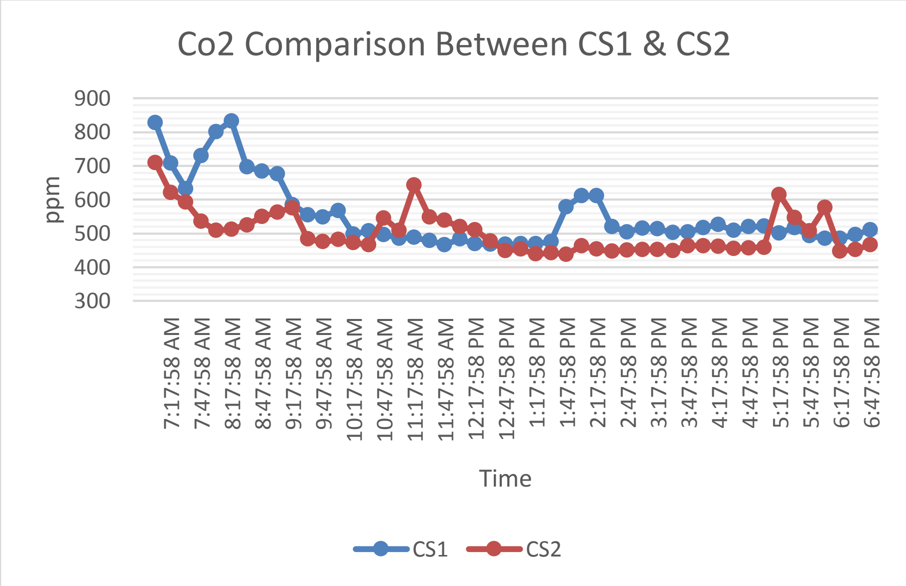

Figure 8 : Co2 Comparison between CS1 & CS2

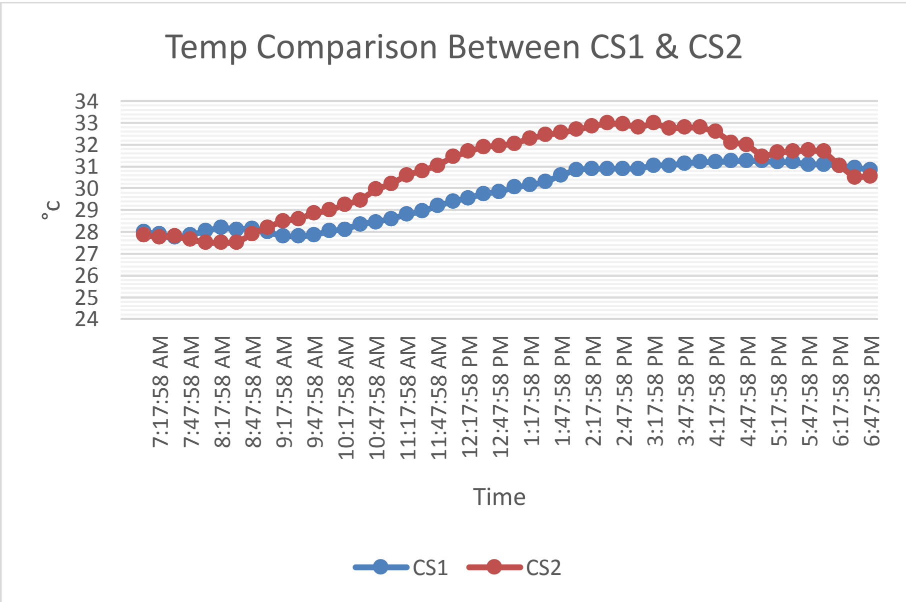

Figure 9 : Temperature Comparison between CS1 & CS2

Figure 9 shows the values of air temperature level of CS1 and CS2, whre there are similar pattern throughout the day, with just minimal changes. Both variables' general trends seem to be stable, with CS1 and CS2 maintaining comparable values. The range of values for CS1 and CS2 is rather constrained. CS1 falls between 28 °C and 31.4 °C, whereas CS2 falls between 27.5 °C and 33 °C. This shows that CS2's range of values is somewhat bigger than CS1's. Without any abrupt or significant fluctuations, both CS1 and CS2 exhibit constant values throughout the day. This implies that the humidity level for both variables is constant and steady. However, even CS1 and CS2 share many trends and ideals, they also differ slightly. Although there is no statistically significant difference between CS1 and CS2, CS1 tends to have somewhat higher values.

To be conclude, based on above graphs, the comparison between opening which is window of both case study can be done. As be mentioned earlier, the CS 1 is using the casement while the CS 2 is using louver. With the aids of recorded parameters, the CS 1 able to allow more relative humidity into the building than CS 2. The casement window on CS 1 typically known as ‘open fully’ which will allow the maximum airflow into the building that could facilitate better ventilation and moisture control.

Then, through the Co2 graph, the greater change of Co2 can be seen on CS 1 with its casement window that provide larger opening in order to facilitate more effective ventilation and the removal of Co2. However, the higher Co2 that be detected within the CS1 actually due to cooking activities that produce quite amount of Co2 while at CS2 the owner is rarely cooking.

After that, in term of temperature, the CS1 show the increasing reading as the day move to the noon because casement window on CS1 have larger glass area compared to louver window on CS2 which would allow more sunlight into the room. This will increase the exposure to direct sunlight that result to the higher solar heat gain and cause the higher temperature near the casement window.

CONCLUSION

The research highlights how casement windows might improve ventilation and moisture control while also acknowledging the possible drawbacks of greater solar heat input. Although the casement window recorded higher temperature data than the louver window, with its fully open feature, the casement window able to allow more ventilation and air change into the building which will circulate the RH and Co2 better than louver window. This type of window able to improve indoor air quality in order to create fresh comfortable environment.

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