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"Sustaining the Resilient, Beautiful and Safe Cities for a Better Quality of Life"

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A CASE STUDY ON EFFECT OF AIR MOVEMENT AT TRAIN PLATFORM

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Abstract

Nowadays, train station is a common transportation used by people and gradually increases in popularity due to walkable city approach. Comfortability at the platform are important as all passenger use the space and it is improving for user convenient, safety and security according to location needs. Under ventilation aspect, air movement are important because the tunnelling effect of present platform design have to meet passenger comfort and standard. Issue such as crowded people, train movement, heat, dust and air pollution by train adding with the pandemic virus Covid-19 create new opportunities of study on air movement. The methodology of investigation is field measurement conducted in KL Sentral using Extech 45160 3 in 1 Anemometer and questionnaire survey with 21 questions answered by 70 respondents. Based on the method, this paper analyses and comprehensively evaluates the ventilation indicator of thermal performance of KTM KL Sentral station platform. The results show an average air velocity of 0.05 – 0.16 m/s, an average air temperature of 30.75 – 33.03 ℃, and an average humidity of 62.63 – 72.30%. Most of the platform users hardly accept the air velocity and air temperature, while 60% of users agreed that the relative humidity is dry or a little dry. The acceptability range for user at the train platform were found to be for air velocity is more than 0.15 m/s, indoor air temperature is 26℃ and relative humidity is 65-75%.

***Keywords**: Railway Station, Train Platform, Air Movement, Ventilation*

INTRODUCTION

Malaysian governments are urging cities to design railway systems link to urban transportation system. Using railway system can reduce traffic congestion and ready for increasing on population. Furthermore, it will create new image of a contemporary city and reduce pollution by carbon emissions (Nordin N.H. et al., 2016). Railway stations are used to transfer goods and people but it is evolving for multipurpose function such as user's walkable transportation network, commercial centre, event gathering location and culture identity landmark (Dingjan M., 2011).

According to Huang & Shuai (2018), comfortable station is important as most train passenger use train to travel influence by comfortability and aimed for relaxation without travel tiredness. Lam, W.H.K. et al., (1999) also stated that on-board crowding is determined by passenger distribution on stations, and vice versa. This is support by (Nakano & Tanabe, 2019) that said desire of comfort are on demand as economic effect are put on priority. Mass passenger movement daily provide advantages for commercial but comfortless must be considered.

The platform area is chosen as an important space to focus as it is highly usable transit space with instant crowd of passenger entering and exiting the train coaches. This is agreed by (Nakano J. et al., 2006) that comfort level is intended vary depending on space function and environmental factor. Enclosed space is a space surrounded by a structure with few openings, such as windows, doors, skylights, or a patio, while open space is a space with a large opening, few walls, or other barriers. (Tarboush R.M. & Ercin C., 2021). In open or semi-open spaces of train platform, ambient control technique is useful to achieve comfort and energy efficiency. Using train sheds would cause direct sunlight to the train platform. According to Nakano J. et al. (2006), the difference reached over 10 ℃ in platforms due to direct solar radiation in some locations. Enclosed dedicated waiting spaces should be planned for continuous period passengers. (Nakano J. & Tanabe S., 2019).

The design for open and enclosed platform are connected through times according to the needs and technology improvement. According to Anuar, N.H. et al. (2021) train-sheds is a structure for shelter, either adjacent to the station building or having roof coverings over the tracks and platforms. Most of the station buildings in Malaysia do not have train-sheds as the current generous overhanging roof eaves normally seen in the station buildings are part of the main building.

Foljanty K. (2014) also said that the first train shed are simple and have low pitched roof like a shed. The sides are open and the needs for great height and width of the sheds were obligatory to disperse locomotives smoke. Later, arched roof was used to free the platform with larger span. Hence, enclosed space was introduced through evolution of the train shed. Through observation, KTM KL Sentral train platform was considered semi open train platform with concrete structure due to the tunnel opening of the train for entrance and exit have short distance and on ground level.

The aim of this paper is to identify the effect of air movement and its related factor of thermal performance in a train station focusing on the platform. For this paper, field measurement and questionnaire survey were used as the method to gain data on ventilation study at the train platform. The data collected are tabulated in table and graph to be compared their relationship between each parameter. The focus of research studies was investigating the current reading of air velocity, air temperature and relative humidity in KTM KL Sentral train platform with questionnaire survey as support from users.

LITERATURE REVIEW

Comfortable indoor environment contributes to high performance and excellent work quality of the occupants. Thermal performance is a result of an adaptation of parameters of the environment without effect of the human body. In line with the Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (MS 1525,2007) have measured the parameter of air temperature, relative humidity and air speed to determine thermal performance value.

In comparison to the average minimum, the average maximum of the indicators is seen to be highly significant. Extremely high air temperatures, high relative humidity, sun radiation, and strong external winds can all have a substantial effect on how well an indoor thermal performance. Among the most important thermal comfort factors for the enclosed spaces is air velocity close to the Earth's surface. The strength and speed of the external air velocity must be measured in order to comprehend the indoor thermal performance. Relative humidity is a significant factor that influences thermal environment in the tropics. High moisture content is another important component that leads to thermal discomfort along with year-round high air temperatures. The lowest air temperatures, which are on rainy days or at night, are when high relative humidity typically occurs. (Leng P.C., 2020).

In order to have a guideline for evaluating the physical measurements, the Malaysian standards were analysed. Table 1 is a summary of the MS:2680, 2017 and MS:1525, 2007 standards with the main parameters recommended for IAQ evaluation. According to Meng Huang et al. (2017), thermal comfort physical parameter index is air temperature, relative humidity and air velocity.

Table 1
Thermal comfort standards and the physical parameter index

Thermal comfort standard	Air temperature	Relative humidity	Air velocity/speed
Department of Malaysian standard (DOSM) (MS:2680, 2017)	23.6 to 30.8°C	55% at 24°C	0.25 to 0.5 m/s
Department of Malaysian standard (DOSM) (MS:1525, 2007)	23 to 26°C	60 to 70%	0.15 to 0.5 m/s
ASHRAE 55—2010	21.5~26.5℃	54 % to 78%	≤0.8 m/s（t0≥25.5℃） ≤0.15 m/s（t0＜25.5℃)

There are four indicators of technology control for comfort that is ventilation, heat, light and acoustics. Ventilation have four controlled parameters that is air temperature, air velocity, air humidity and air quality (Pisello A.L. et al., 2021). Ventilation indicator are used according to specific space function and usage. Ventilation efficiency also can be obtained by considering heat effect and pollutant dispersion according to Yang, H., et al. (2007).

Hu S.C. et al. (2008) stated that more airflow and ventilation is required to reduce air temperature. The highest air temperature is when the train stops at the station and the piston effect of train moving in the tunnel will reduces air temperature. Air velocity affects both convective and evaporative heat losses from the human body, and thus influences thermal comfort conditions. Results of a tests indicate that when subjects working at a moderate level of activity, comfort is as good with the higher air velocity, and results showed a higher sensitivity to temperature than predicted by either model (Meng Huang et al., 2017).

From the literature review, the most issue on the train platform is the passenger thermal comfort (Nakano J. et al., 2006; Nakano J. & Tanabe S., 2019; Huang M. & Lin Y., 2017; Adibi O., Farhanieh B. & Afshin H., 2015). The issue of heat, dust and air contamination also caused a major problem at train platform (Olander L., 2016; Lagundino M.N. & Manuel M.C. E., 2020). However, the energy saving issue by Hu S.C. et al. (2008) and safety emergency matter by Hu L. et al. (2013) are also considered. The distance between tunnel entrance and platform are also another issue according to Maevski I.Y. & Civil J. (2006).

The solution suggested are to increase air velocity at the train platform, install a set of baffle plates to direct tunnel airflow (Maevski I.Y. & Civil J., 2006). Openable skylight on the roof as solution of wind speed issue and four skylights arranged symmetrically in two rows in the lighting atrium have greatest effect on ventilation of platform (Han X. et al., 2020). According to Hu L. et al. (2013), over track exhaust (OTE) system can control the smoke more effectively and by using platform smoke exhaust mode can make lower temperature and best visibility for evacuation during crowd fire emergency exit. Olander L. (2016) said that by connecting tunnel directly to station can reduce air velocities during train movements. According to Lagundino M.N. & Manuel M.C.E. (2020), push-pull ventilation also can be used to control smoke direction away from the people to provide a safe escape pathway.

There are limited study in same location for the study of thermal performance at the platform. At the same location, there are circulation study by Yao W.Y. et al. (2018), user perception study by Bachok S. et al. (2013) and the level of indoor air quality using number of passengers, temperature, relative humidity and CO2 concentration parameters (Mahmood W.H.W. et al., 2018). The study stated that there is a strong relation between air quality and health inside the train. Long exposure to high air temperature and carbon dioxide concentration could have acute health symptoms such as fatigue, dizziness, dry nose, dry eyes and others.

METHODOLOGY

The research also will provide information on a potential to influence on how the designers or architects to design a future train terminal specifically on the platform. The investigation was done in two phases. In the first phase, a site visit and experimental field measurements were conducted at KL Sentral in train platform to collect the data on air velocity, air temperature and relative humidity. In the second phase, questionnaires about the air velocity, air temperature and relative humidity were supplied to the user of the KTM commuter.

Field Measurement

For this phase, the performance of thermal parameter can be determined. Highest and lowest data of air velocity, air temperature and relative humidity can provide the input on ventilation at the train platform.

Figure 1

a) *A pictures with Keretapi Tanah Melayu Berhad (KTMB) Officer (b) KL Sentral aeriel view by klia2.info (c) Internal Layout of KL Sentral station*

b) *The case study building, Kuala Lumpur Central Station (KL Sentral), is about 1.5 kilometres from the city's commercial centre and is situated southwest of Kuala Lumpur. Stesen Sentral, also known as Malaysia's largest and best-in-class transportation hub, effortlessly connects all urban and suburban housing, business, and manufacturing regions while providing worldwide connection. Six rail systems connect to Kuala Lumpur International Airport (KLIA), Putrajaya, the Federal Government Administrative Office, and key highways: KLIA Express Rail Link, KLIA Transit, RAPID KL, KTM Komuter, KTM Intercity, and KL Monorail Services (Yao, W. Y., et al., 2018).*

Keretapi Tanah Melayu (KTM) KL Sentral were chosen because the design of platform that are almost like a tunnel where it develops many issue to be solved. Although it is considered semi open train platform with concrete structure due to the tunnel opening of the train for entrance and exit have short distance and on ground level, the most priority issue is ventilation. KTM KL Sentral have 6 platforms for the train, 2 for Electric Train Service (ETS) and 4 for KTM komuter. KTM komuter platform 5 and 6 going to Sungai Gadut and Batu Caves respectively. These platforms were chosen due to the opening of escalator from upper floor was not disturbed by direct sunlight compare to other platform.

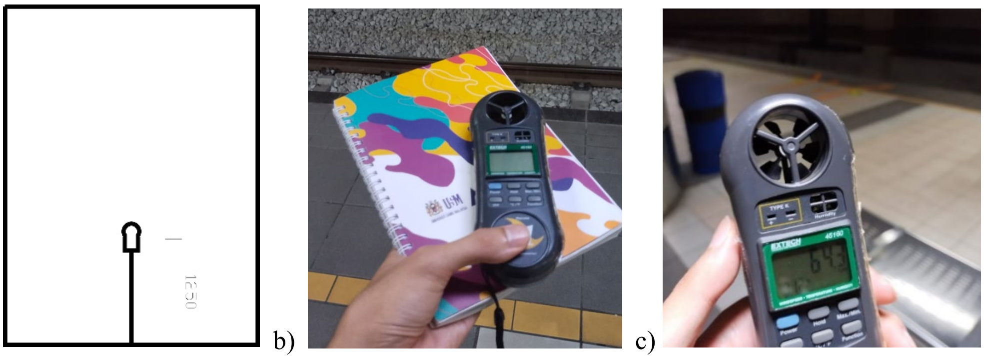
Extech 45160 3 in 1 Anemometer was used to measure wind speed, temperature and humidity of the platform. 27 point of reading were taken along platform 5 and 6 mark from (a) until (@) in figure 2 and 3. The unit used during the measurement are degree Celsius(C) for air temperature, the percentage of relative humidity and feet per minute (fpm) for wind speed then later converted into meter per second (m/s). Figure 4.

Table 2
Specifications of measuring equipment

Name	Range	Accuracy	At height
Extech 45160 3 in 1 Anemometer	80 to 5910 ft/min, 0.4 to 30m/s, 0 to 50°C, 10 to 95%RH	±3%, ±1.2°C, ±4%RH of reading	1250 mm

Figure 2
a) Height of equipment during measurement taken b) Recording data c) Collecting data.

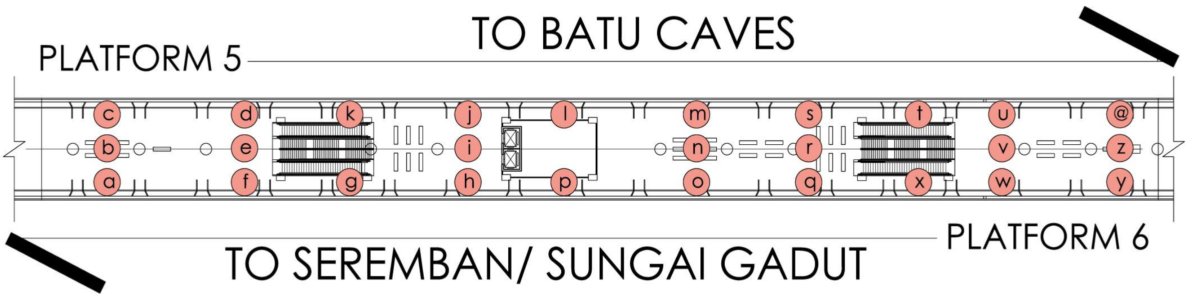
a) b) c)



The temperature of outside (outdoor temperature) also taken to compare between each time the measurement was conducted. The field measurement was conducted for 3 days from 11 until 13 May 2022 at 8 am, 10.30 am, 12 pm, 1.30 pm, 3pm, 4.30 pm and 6 pm shown in table 2. The measurement was conducted between 8 am until 6 pm because it is the peak hours of commuter's users. The gap of one hour were lengthen to one hour and thirty minutes is to produce a bigger difference between each time the measurement was conducted and also to avoid the effect of air conditioning from train that arrive at both platforms. The room ceiling height is 3.5 meter at the platform and 8.5 meter at the railway track. The opening at the platform is from the upper floor for escalator and stairs. 27 point of reading were taken along platform 5 and 6 were mark according to A-Z alphabet. While the opening for train is at both end of the station track. The ventilation system used at the station platform is the exhaust fan and wall fan.

Table 2

Detail of Conducted Field Measurement.



Location	Date	Weather Conditions	Time of Measurements	Average Indoor Temp. (°C) at level 2
KTM KL Sentral train platform	11 May 2022	Sunny	8.00 am	28.3
			10.30 am	31.5
	12 May 2022	Mostly clear	12.00 pm	32.1
			1.30 pm	30
	13 May 2022	Partly Cloudy	3.00 pm	32.5
			4.30 pm	31.3
			6.00 pm	30.3

The data collected have been tabulated according to point taken, day and time. All units for measurement are the same except for wind speed that later been converted into meter per second (m/s). Then, a new table have been produced to find the average of the data of each day. The table rearrange according to air speed, air temperature and relative humidity. The data can easily be observe and compare. For the final graph of each part, the average of the data for time been calculated and prepared. The highest, lowest and standards also been tabulated in the graph. During data collection, the arrival of train and mechanical fan produce some limitation because it might have some effect on reading although it's have been avoided continuously.

Questionnaire

For this phase, the perception of thermal performance can be determined. The data collected from field measurement at the train platform can be validated with the survey from users. The questionnaire consisted of 21 questions including aspects of demographic information, such as gender, age, occupation including about the station using time, clothes, location and frequency of using the platform (appendices A). The focus of the question is on the user perception and the effect of the ventilation and indoor air quality at the station platform including air speed, air temperature and relative humidity. The questionnaire was distributed using google form link from 1st June 2022 until 10th June 2022. Before participating for the questionnaire, respondent will have to read and understand the purpose of the study. The respondent has unlimited time to answer but the question will reboot if the respondent does not finish the questionnaire. The study presents some limitations, time and legal constraint have made the questionnaire to be answered online rather than at the platform directly.

RESULTS AND DISCUSSION

Effect of Daylighting on Transparent Concrete

The results from field measurement compiled and the average values from each day of conducting research were obtained, as seen on table 3, 4 and 5. Table 3 show that the Air Velocity (m/s) research data average day value at each time on the platform. The maximum average speed is 0.44 m/s, while minimum average speed is 0.05 m/s. Table 4 show that the Air Temperature (°C) research data average day value at each time on the platform. The maximum average temperature is 33.53°C, while the minimum average temperature is 29.4°C. Table 5 show that the Relative Humidity (%) research data average day value at each time on the platform. The maximum average percentage is 76.45%, while minimum average percentage is 60.97%.

Table 3, 4 and 5

3 days average data of Air velocity, Air temperature and Relative humidity.

	Air Velocity m/s						
	8.00 am	10.30 am	12.00 pm	1.30 pm	3PM	4.30 pm	6.00 pm
a	0.16	0.19	0.44	0.40	0.29	0.16	0.27
b	0.00	0.00	0.11	0.05	0.11	0.11	0.05
c	0.08	0.21	0.16	0.32	0.21	0.11	0.10
d	0.08	0.27	0.16	0.14	0.11	0.22	0.11
e	0.16	0.11	0.27	0.37	0.26	0.21	0.36
f	0.00	0.19	0.10	0.10	0.22	0.11	0.16
g	0.00	0.20	0.10	0.35	0.22	0.05	0.10
h	0.08	0.05	0.11	0.05	0.16	0.00	0.00
i	0.00	0.00	0.00	0.05	0.00	0.00	0.00
j	0.00	0.00	0.14	0.18	0.00	0.00	0.11
k	0.00	0.14	0.05	0.10	0.05	0.00	0.00
l	0.00	0.14	0.05	0.21	0.10	0.05	0.05
m	0.16	0.03	0.05	0.21	0.16	0.16	0.00
n	0.16	0.03	0.10	0.14	0.00	0.05	0.00
o	0.08	0.00	0.16	0.28	0.05	0.00	0.00
p	0.00	0.03	0.10	0.29	0.05	0.00	0.05
q	0.00	0.05	0.16	0.10	0.13	0.00	0.00
r	0.00	0.00	0.05	0.05	0.05	0.00	0.00
s	0.00	0.05	0.11	0.16	0.00	0.05	0.00
t	0.08	0.05	0.10	0.16	0.21	0.00	0.11
u	0.00	0.05	0.00	0.00	0.05	0.10	0.05
v	0.00	0.07	0.21	0.32	0.21	0.16	0.21
w	0.00	0.00	0.05	0.25	0.05	0.10	0.05
x	0.00	0.00	0.05	0.20	0.05	0.16	0.00
y	0.00	0.10	0.05	0.05	0.05	0.05	0.05
z	0.00	0.03	0.05	0.00	0.00	0.00	0.00
@	0.08	0.15	0.16	0.16	0.11	0.11	0.31

Air Temp
Degree Celcius

	8.00am	10.30 am	12.00 pm	1.30pm	3pm	4.30pm	6.00 pm
a	29.4	31.13	31.70	31.40	32.57	31.60	30.97
b	29.45	31.07	31.83	31.53	32.73	31.80	31.07
c	29.55	31.17	31.83	31.57	32.87	31.83	31.10
d	29.7	31.23	31.77	31.63	33.00	31.90	31.17
e	29.7	31.20	31.83	31.73	32.73	31.93	31.30
f	29.8	31.20	31.90	31.73	32.73	31.97	31.37
g	30.2	31.27	31.90	31.77	32.73	32.07	31.80
h	30.25	31.37	31.90	31.83	32.90	32.10	31.83
i	30.25	31.37	31.97	31.90	33.23	32.13	31.80
j	30.25	31.37	31.97	31.83	33.30	32.17	31.90
k	30.55	31.43	31.93	31.90	33.50	32.17	31.93
l	30.45	31.37	31.93	31.97	33.53	32.17	32.13
m	30.75	31.43	32.07	32.00	33.37	32.17	32.13
n	30.75	31.47	32.10	31.97	33.33	32.17	32.10
o	30.75	31.50	32.13	32.40	33.03	32.17	32.13
p	30.85	31.47	32.07	32.40	33.03	32.20	32.10
q	31	31.50	32.07	32.30	33.03	32.13	32.20
r	31.05	31.57	32.17	32.33	33.27	32.17	32.17
s	31.1	31.60	32.17	32.43	33.27	32.13	32.13
t	31.15	31.57	32.10	32.30	33.33	32.17	31.97
u	31.2	31.60	32.13	32.37	33.27	32.20	32.07
v	31.15	31.63	32.23	32.40	33.27	32.30	32.10
w	31.25	31.70	32.27	32.40	33.23	32.30	32.17
x	31.25	31.73	32.23	32.37	33.17	32.33	32.17
y	31.2	31.77	32.13	32.37	32.97	32.27	32.10
z	31.25	31.77	32.23	32.47	33.03	32.30	32.13
@	31.3	31.73	32.27	32.50	33.03	32.33	32.17

Relative Humidity
%

	8.00 am	10.30 am	12.00 pm	1.30 pm	3.00 pm	4.30 pm	6.00 pm
a	76.45	68.83	65.73	66.60	63.90	68.97	71.13
b	76.35	68.47	65.17	65.20	63.20	68.50	70.20
c	76	68.23	65.40	65.13	62.93	68.23	69.80
d	75.25	68.40	65.40	65.40	62.30	68.23	69.67
e	75.2	68.17	64.27	64.43	62.60	67.07	68.77
f	75.1	68.77	64.83	65.17	63.07	67.93	68.87
g	73.85	68.63	65.00	65.20	62.60	68.27	68.60
h	73.6	68.60	65.10	65.17	62.80	68.27	68.40
i	73.45	68.47	64.93	65.20	62.23	68.17	68.80
j	73.4	68.53	65.07	65.37	61.90	68.07	68.93
k	72.7	68.60	64.97	64.83	60.97	67.80	68.20
l	73.1	68.53	64.70	64.83	61.23	67.67	68.00
m	72.3	68.03	64.67	65.20	61.83	67.90	68.57

n	72.2	68.17	64.53	64.93	61.90	67.87	68.47
o	72.3	68.10	64.20	64.43	62.63	68.00	67.80
p	72.2	68.03	64.30	64.43	62.87	68.13	67.83
q	71.85	68.00	64.37	64.73	63.40	68.23	68.10
r	71.25	67.97	64.23	64.53	62.53	67.93	67.50
s	70.5	67.93	64.33	64.37	62.27	67.60	67.93
t	70.55	67.63	64.13	64.57	61.87	67.63	68.63
u	71.5	67.83	63.77	64.50	62.47	67.57	69.03
v	70.3	67.67	63.63	63.80	62.93	67.80	68.97
w	70.85	67.60	63.93	64.53	63.00	67.50	68.73
x	70.7	67.70	63.73	65.27	62.83	67.47	68.07
y	70.75	67.60	64.23	64.53	63.87	67.53	68.67
z	70.55	67.30	63.90	64.87	63.93	67.60	68.47
@	70.75	67.60	63.90	64.53	64.30	66.77	68.90

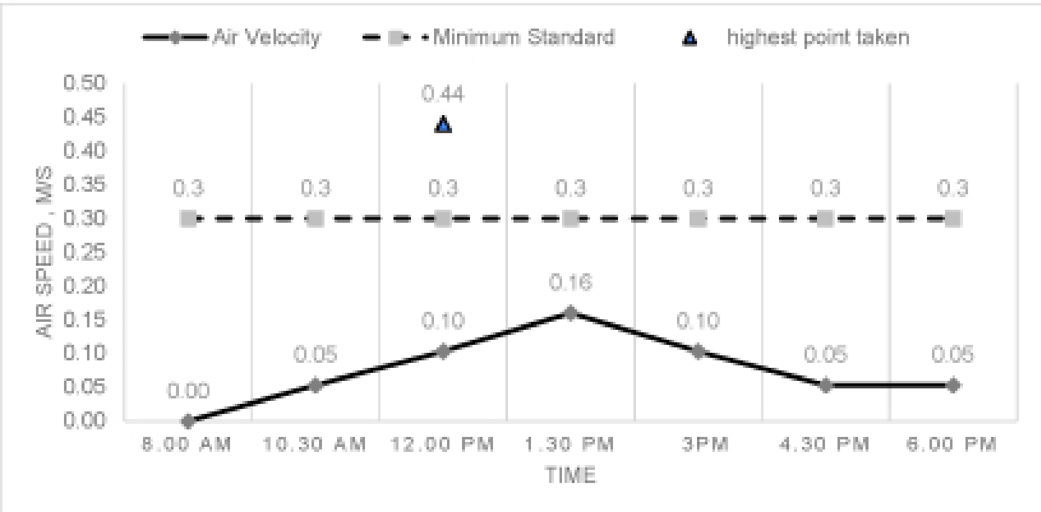
For questionnaire survey, the total of 70 responders have answered the questionnaire. This number of respondents corresponds to 52.9% of female respondents and 47.1% of male respondents, with age between 15-24 for 51.4%, age between 25-54 for 42.9%, 55-64 years old for 4.3% and 1.4% for over 65 years old. Most of the respondent are students compare to self-employed, unemployed and retired. From the 70 respondents, 67.1% rarely using the station platform while 21.4% using the station weekly and 10% used it daily. The time of the respondent using the platform are mostly varies without specific to any time. Most of the respondent wear one layer of clothes during they used the station platform. The most comfortable spot for the respondents as the platform user is at 3A, 4A, 3B and 1A.

Air Velocity

Statistical results of air velocity data at different points were shown in figure 4. At the platform, the air velocity ranged from 0 to 0.44 m/s and the average air velocity was 0.1 m/s. According to The Malaysian standard (MS:2680, 2017), it recommends the suitable air velocity varied from 0.25 to 0.5 m/s. Therefore, the air velocity at the platform was relatively low.

Figure 4

Average Air Velocity of the station platform



The user's air velocity scale is divided into five evaluation levels (Table 6). 47.1% users voted for 1- stagnant and only 25.7% voted noticeable. The majority and differences of percentage means that the user felt that the air velocity was also low.

Table 6
Question 8 of the questionnaire (Rate the air velocity at platform without train)

Scale	1 – Stagnant	2 - Noticeable	3 -Comfortable	4 - Good	5 – High
Vote	33 (47.1%)	18 (25.7%)	16 (22.9%)	2 (2.9%)	1 (1.4%)

This situation improved slightly when the train enter the platform area, but majority of users still voted 1-stagnant and 2-noticeable with 62.4% accumulatively. (Table 7).

Table 7
Question 9 of the questionnaire (Rate the air velocity at platform with train)

Scale	1 – Stagnant	2 - Noticeable	3 -Comfortable	4 - Good	5 – High
Vote	22 (31.4%)	22 (31.4%)	16 (22.9%)	2 (2.9%)	1 (1.4%)

The result for dust level at station platform show that's majority voted 3-moderate that could be considered as acceptable level but for 5-high level is still big percentage of 20%. These results confirm by the users who are having symptoms that are 44.3% with varies symptoms. (Table 8).

Table 8
Question 10,11 and 12 of the questionnaires.
Rate the dust level in the air at station platform

Scale	No Dust	1 – Low	2 – Slightly Low	3 - Moderate	4 - Slightly high
Vote	3 (4.3%)	7 (10%)	5 (7.1%)	32 (45.7%)	9 (12.9%)

Do you feel any symptoms?

Scale	No	Dry eyes	Dry throat	Dry skin	Runny nose	Headache	Sweating
Vote	39 (55.7%)	10 (14.3%)	2 (2.9%)	4 (5.7%)	9 (12.9%)	5 (7.1%)	1 (1.4%)

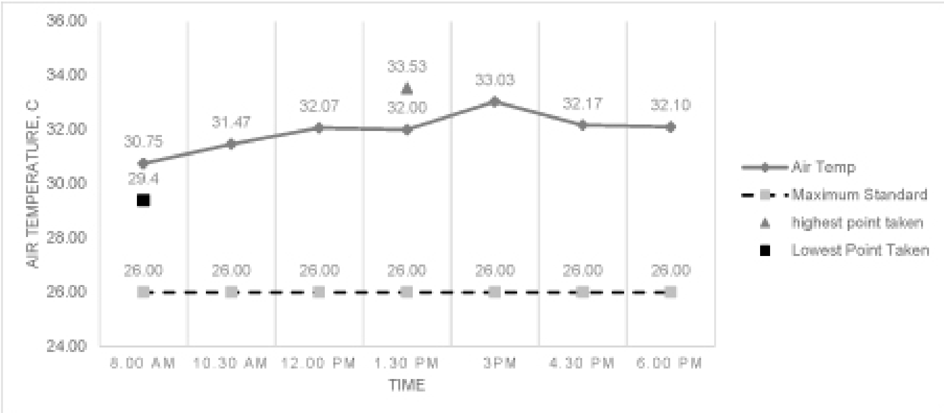
Do these symptoms disappear when you leave the building?

Scale	Yes	No	Sometimes	Not Applicable
Vote	20 (28.6%)	8 (11.4%)	10 (14.3%)	31 (44.3%)

Indoor Air Temperature

Statistical results of air temperature data at different points were shown in figure 5. At the platform, the air temperature ranged from 29.4 to 33.53°C and the average air temperature was 32°C. The Department of Malaysian standard (DOSM), 2007 recommends the guideline for a standard indoor environment design for Malaysian climate from 23 to 26°C, so the air temperature at the platform was very high.

Figure 5
Average Air Temperature of the station platform



The user's temperature scale is divided into five evaluation levels (Table 9). 48.6% users voted for 4-slightly warm and 28.6% voted good. Majority of percentage means that the user feel that the air temperature is slightly high although there is still user that comfortable with the temperature.

Table 9
Question 13 of the questionnaires.
Rate the temperature at platform without train (without fan or etc. effect)

Scale	1 – Low	2 – Slightly Low	3 - Good	4 – Slightly warm	5 – High
Vote	7 (10%)	3 (4.3%)	20 (28.6%)	34 (48.6%)	6 (8.6%)

The users voted that the platform air temperature become higher when the train enters, this is due to the congested and crowded feeling that can be feel as the wall and ceiling are fully close (Table 10).

Table 10
Question 14 of the questionnaires.
Rate the temperature at platform with train (without fan or etc. effect)

Scale	1 – Low	2 – Slightly Low	3 - Good	4 – Slightly warm	5 – High
Vote	6 (8.6%)	3 (4.3%)	21 (30%)	22 (31.4%)	18 (25.7%)

Most of the users voted in table 11 for much cooler (35.7%) and slight cooler (42.9%) for the thermal preference show that the platform area air temperature is high. In table 11, the rate of the level of sweating are still moderate (42.9%) but the percentage are leaning towards high with 28.6 % for 4-slightly high and 15.7% for 5-high. This is also another support for the data gained.

Table 11
Question 15 and 16 of the questionnaires.
What are your thermal preference rate of the station platform?

Scale	1 – Much Cooler	2 – Slightly Cooler	3 – No Change	4 – Slightly warmer	5 – Much Warmer
Vote	25 (35.7%)	30 (42.9%)	13 (18.6%)	2 (2.9%)	0

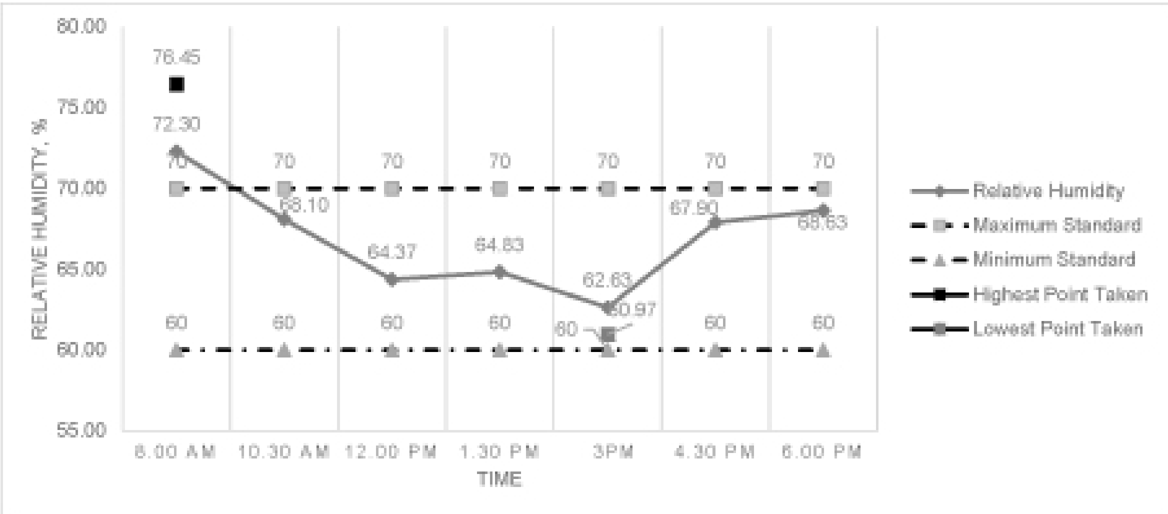
Rate the level of sweating in the station platform

Scale	No Sweat	1 – Low	2 – Slightly Low	3 - Moderate	4 - Slightly high
Vote	4 (5.7%)	3 (4.3%)	2 (2.9%)	30 (42.9%)	20 (28.6%)

Relative Humidity

Statistical results of relative humidity data at different points were shown in figure 6. At the platform, the air humidity ranged from 60.97 to 76.45% and the average relative humidity was 66.97%. The Department of Malaysian standard (DOSM), 2007 recommends the standard indoor environment design for Malaysian climate from 60 to 70%, so the humidity at the platform are still acceptable although it is still high in the morning.

Figure 6
Average Relative Humidity of the station platform



The user's humidity scale is divided into five evaluation levels (Table 12). 40% users voted for 2-a little dry and 28.6% voted moderate. This is shows that the user feel that the humidity is slightly dry. While the air quality is voted slightly uncomfortable and neutral.

Table 12
Question 17 and 18 of the questionnaires.
How do you perceive the humidity at the station platform?

Scale	1 – Dry	2 – A Little Dry	3 – Moderate	4 – A little Wet	5 – Wet
Vote	14 (20%)	28 (40%)	20 (28.6%)	6 (8.6%)	2 (2.9%)

Rate the air quality at the station platform.

Scale	1 - Uncomfortable	2 - Slightly uncomfortable	3 - Neutral	4 - Slightly comfortable	5 - Very Comfortable
Vote	19 (27.1%)	24 (34.3%)	24 (34.3%)	3 (4.3%)	0

Table 13
Summary of findings

Thermal Performance Data	Air temperature	Relative humidity	Air velocity
Average Data Collection	30.75 – 33.03 ℃	62.63 – 72.30%.	0.05 – 0.16 m/s
Acceptability Range (MS:1525, 2007)	26°C	60-70%	0.15 to 0.5 m/s

User's Perception About Train Platform

- Stagnant air velocity (47.1%) at platform improve slightly when train enter (31.4%)
- Dust level is moderate (45.7%)
- Symptoms at the train platform is dry eyes (14.3%) and runny nose (12.9%)
- Indoor air temperature at platform is slightly warm (40.6%) and improve slightly when train enter (31.4%).
- The thermal preference of users is slightly cooler (42.9%) and much cooler (35.7%)
- Relative humidity on platform is little dry (40%)
- Air quality is uncomfortable (27.1%) and slightly uncomfortable (34.3%)

The relationship of air velocity, air temperature and relative humidity in this measurement study are when the air temperature is high, relative humidity is low. So, the air temperature is inversely proportional to relative humidity. However, the air velocity is varying according to the air movement through the main station. Higher air velocity will reduce the hot air temperature of the surrounding and provided better indoor thermal comfortability for user. Hence, high movement of air produce cooler air temperature and higher air humidity of surrounding. To achieve higher comfortability at KTM KL Sentral platform station, air temperature at 12.00 p.m. until 4.30 p.m. have to be reduced mostly at 3.00 p.m. Hence, the relative humidity of that time will increase but the air humidity at 8.00 a.m. should be slightly reduced. Existing studies have found significant positive relationship between number of passengers and CO2 level inside the train. High concentration of CO2 level would give acute health symptoms to the passengers. In this research, low air velocity at the train platform also gives mild symptoms to the users. Continuous bad effect of thermal performance on users would increase the chance of further symptoms. Therefore, a more comprehensive study is recommended to expand the research to wider variable, multiple platform design and systems.

CONCLUSION

Based on this study, it found that air movement have a significant impact on the indoor thermal performance in a building. The design and system used at the train station platform shows a vital influence in the study of ventilation. It can be concluded that:

i. The most measured parameter to determine thermal performance are air temperature, air velocity and relative humidity.

ii. Thermal comfort standards should be followed although some user's perception may be varies. A majority of number in a user perception group can support and validate the data collection as the author show that it is mostly synchronise.

iii. The main contribution of the study is low air movement of 0.05 m/s with little opening in an enclosed train platform area can give mild symptoms of dry eyes and runny nose to the users. The comfortability of enclosed train platform is much higher than 'train shed' platform due to the uncertainty of surrounding impact. Although that, the results show an average air velocity of 0.05 – 0.16 m/s, an average air temperature of 30.75 – 33.03 °C, and an average humidity of 62.63 – 72.30%. Most of the platform users hardly accept the air velocity and air temperature, while 60% of users agreed that the relative humidity is dry or a little dry.

iv. Although there are both quantitative and qualitative data, the study presents some limitations:
   - There are 62.9% of respondent are student and 67.1% of respondent rarely used the station platform. This means the questionnaire data are still low on consistent users.
   - Earlier in the study suggested a comparative case study of two train station platform but KTM KL Sentral were chosen due to its design and location of platform at lowest level. Questionnaire survey method have been introduced to support the measurement data to have a better understanding on user's comfortability.
   - During data collection, the arrival of train and mechanical fan might have some effect on reading although it's have been avoided continuously.

v. However, this study only based in one train station in Kuala Lumpur, hence a more comprehensive study is recommended to expand the research to wider variable, multiple design and systems. Further study also recommended to determine the applicability and practicability of various mix-mode ventilation strategies focusing more on crowd evacuation during fire escape.

vi. A better understanding on user's perception and concerns will ultimately help in creating a better train station that are more efficient and also safer for people and environment.

vii. The results show an average air velocity of 0.05 – 0.16 m/s, an average air temperature of 30.75 – 33.03 °C, and an average humidity of 62.63 – 72.30%. Most of the platform users hardly accept the air velocity and air temperature, while 60% of users agreed that the relative humidity is dry or a little dry. The acceptability range for user at the train platform were found to be for air velocity is more than 0.15 m/s, indoor air temperature is 26°C and relative humidity is 65-75%.

Table 14
Summary of findings

Thermal Performance Data	Air temperature	Relative humidity	Air velocity
Average Data Collection	30.75 – 33.03 ℃	62.63 – 72.30%.	0.05 – 0.16 m/s
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