The Effects of Number of Passengers and Duration of Door Opening and Closing Toward Temperature Change (Case Study: KRL Series JR 205 Crossing Manggarai - Depok)

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Abstract. The comfort factor in the KRL room is needed, one of which is the comfort of the air temperature conditions in the train resulting from the air conditioning (AC) process. At peak hours, passengers will pile up on each other in the train room which causes the cold air to not be felt, and passengers will file complaints. This study aims to analyze the effect of the number of passengers and the duration of opening and closing doors partially and simultaneously on changes in temperature that occur in the KRL room, as well as knowing the value of the variables that affect temperature changes in the KRL room. The results of the partial t test show that the number of passengers and the duration of opening and closing doors have a significant effect on changes in temperature in the KRL. The results of the simultaneous F-test research show that the number of passengers and the duration of opening and closing doors simultaneously have a significant effect on temperature changes in the KRL. The result of this analysis is the change in temperature in the KRL as much as 67.2% is influenced by the variable number of passengers and the number of door closings.

Keywords: Air Conditioning · Train · KRL

1 Introduction

Railway mode as a means that has the capacity to transport large amounts of cargo and passengers as well as commuter transportation in big cities. In the Jabodetabek area (Jakarta, Bogor, Depok, Tangerang, and Bekasi), the train transportation mode that can be relied on by the surrounding community is KRL (Electric Rail Train) or Commuter Line. KRL serves local coverage routes available in the Jabodetabek area, KRL's densest trips usually occur during peak hour or work time. KRL has several advantages, namely having a large carrying capacity. In addition, KRL has a special lane that is separated from road transportation and travel time is relatively faster than other transportation [1].

Based on data from the Central Statistics Agency (BPS) of the Republic of Indonesia, the average volume of KRL passengers in 2010–2018 is shown in the Fig. 1.

Figure 1 shows that KRL passengers continue to increase. In terms of the number of trips, recorded in the Train Travel Chart (GAPEKA) in 2020 has increased compared to the Train Travel Chart (GAPEKA) in 2019.

W. A. Wirawan et al. (Eds.): ICORT 2022, AER 220, pp. 164–173, 2023.
https://doi.org/10.2991/978-94-6463-126-5_18

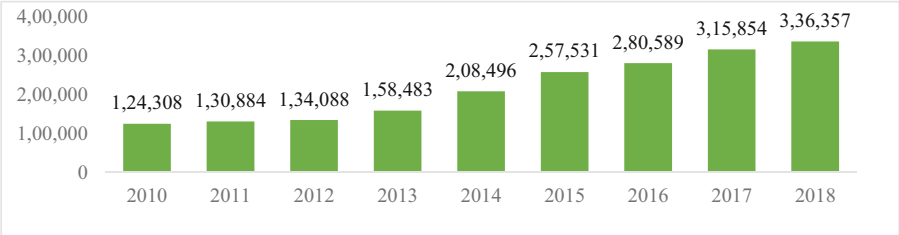

Fig. 1. Number of KRL Passengers in 2010–2018

Table 1. Number of KRL Trips in 2019 and 2021

Line	Number of KRL Trips (Based on GAPEKA 2019 dan 2021)	
	2019	2021
Bogor *Central Line*	248	267
Bogor *Loop Line*	200	209
Bekasi *Line*	175	236
Serpong *Line*	215	237
Tangerang *Line*	116	118
Tanjung Priok Line	56	84
Total	1010	1151

(Source: PT KCI, 2021).

Based on Table 1, the highest number of train trips in 2019 and 2021 is still dominated by KRL across the Bogor Central Line which covers routes from Bogor or Depok to Jakarta City and vice versa. The number of trips across the Bogor Central Line is the line with the most KRL users when compared to the number of passengers on other lines [2].

The comfort factor in the KRL room is needed, one of which is the comfort of the air temperature conditions in the train resulting from the air conditioning (AC) process. AC is needed to provide a comfortable, fresh, and clean room condition. Therefore it is necessary to treat the air circulation process. Based on data from PT KCI, the highest volume of KRL users occurs at 17.00 and 18.00 as shown Fig. 2.

Findings [3] there are three sources of problems that cause additional stop time, including headway between commuter lines in peak hours not in accordance with the number of passengers served, Distance between stations is not evenly distributed, With a total of 10 trains in a series, the capacity of one series does not match the number of passengers served, as a result passengers jostle and force themselves to get into the train. The overcapacity of KRL passengers on weekdays usually occurs at work time. This causes the train to experience delays due to the large number of passengers boarding, resulting in the train doors being open longer and the passenger queue becoming crowded

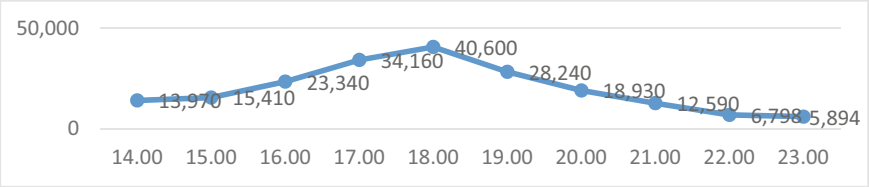

Fig. 2. Average Volume of KRL Passengers per Hour

[4]. At peak hours, passengers will pile up and fill the train room which causes cold air to not be felt. Therefore, the purpose of this study is to identify the relationship between the effect of the number of passengers and the duration of door opening and closing partially and simultaneously on the temperature changes that occur in the KRL room.

2 Literature Review

2.1 Thermal Comfort

Thermal comfort according to ASHRAE definition is the condition of the human mind that feels satisfaction with the condition of a room. Factors that cause humans to feel satisfied and comfortable with room conditions such as room air temperature, temperature radiation on the surface of the room, air humidity, air movement, odors, lighting, acoustics, and the beauty of the room. Humans feel uncomfortable when the room conditions are too hot or too cold plus no air circulation in the room so that the room becomes stuffy and smelly. For that thermal comfort is needed for humans to support the work done by the human. Human thermal comfort indoors (indoor) or outdoors (outdoor) is different, because all these conditions are influenced by internal and external factors of the room [5].

2.2 Cooling Load

According to the ASHRAE Handbook of Fundamentals (1993), the cooling load is the amount of heat transferred by the air conditioning system every day. The cooling load of a room comes from two sources, namely through external sources and internal sources. Internal sources that come from the room include occupants and electrical equipment. While the external source is the amount of heat at any time that enters the room through the glass by radiation or through walls, doors due to temperature differences outside the room. Internal load is the load caused by the components that fill the room. Judging from how many occupants of the room, total hours, and activities carried out by the occupants. External loads are in the form of air entering the building naturally or mechanically through gaps and other openings and due to the use of outdoor doors [6].

2.3 Heat Load from Air Exchange Through Doors

When the door of the conditioned room is open, hot air from outside will enter replacing some of the cold air in the room. This will affect the air temperature in the cooling room.

The heat from this air will be part of the cooling load. The hot air can enter the room through window cracks, doors or other leaks or deliberately flow in (of course within certain limits) for ventilation. If the number of occupants of a room that is conditioned is quite a lot of fresh air that must be entered must be a lot too. In air conditioning (AC) the fresh air is called infiltration load or ventilation load. Called ventilation load if fresh air is intentionally entered for ventilation purposes only, to replace air that has less oxygen with fresh air. While the infiltration load, if the incoming fresh air is infiltration air that enters through the cracks of doors, windows and other parts of the house or room. In every air conditioning system there will be one of the air loads, ventilation or infiltration, but not both [7].

2.4 Heat Load from Number of Passengers

Internal heat load comes from heat generated by occupants. It is also called core load or internal admittance. Humans in carrying out activities emit heat. In calculating the passenger load, data on the heat released by humans is needed. Heat in the body is produced by the metabolic process to maintain body temperature. This metabolic process is influenced by several factors such as age, health and activity level [7].

2.5 Hypothesis and Conceptual Framework

From the theory above, the hypotheses built in this study include:

[8] found that the number of seats as well as operations, namely passenger density and time for each passenger to get on and off, have an effect on cooling. So the hypothesis:

H1 The number of passengers affects the temperature changes that occur in the KRL room.

Research [9] found that during the opening of the sliding door, the temperature area on the side of the sliding door increases as the opening time increases and the average air velocity increases as the train height increases. The average temperature of the passenger train increases as the temperature in the station increases (Fig. 3).

H2 Duration of Door Opening and Closing on the Temperature Changes Occurring in the KRL Room.

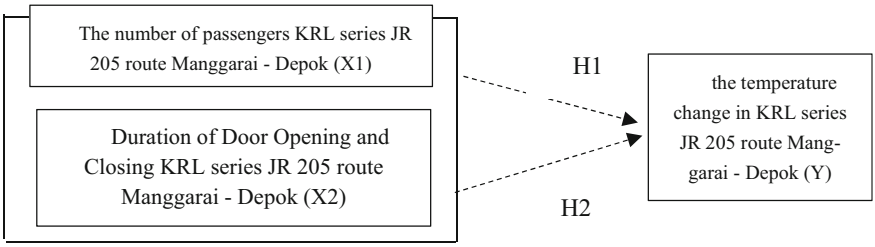

Fig. 3. Conceptual Framework

3 Research Methods

In this study, using primary data obtained from observations in the form of temperature measurement values in the KRL room and the length of time the door is open at each station passed by KRL from Manggarai station to Depok station and questionnaire surveys to KRL passengers from field research results. In addition, it also uses secondary data in the form of JR 205 series KRL AC specification data, and data on the number of JR 205 Series KRL passengers across Manggarai - Depok in January - March 2021.

The sample in this study was taken using purposive sampling method where the researcher has made certain considerations tailored to the research objectives. With a population of 26,556,722 Bogor-Jakarta Kota PP KRL passengers in January 2020-March 2020 obtained from the DAOP I Jakarta passenger transportation unit, the sample to be studied can be calculated using the following formula:

$$n = \frac{N}{1 + [N \times (e2)]}$$

Description:

n = number of sample.
N = number of population.
e^2 = *Margin of error* (0,10).

Based on the calculation using the Slovin formula above, it can be seen that the sample that the researcher must take is 99.9, but the sample is rounded up to 100 respondents. To achieve the research objectives, the data was analyzed using multiple regression with the model:

$$Y = a + b1X1 + b2X2 + ... + \in$$

Description:

Y = Temperature change in the KRL room.
a = Constant.
x1 = Number of passengers.
x2 = Open and close the KRL door.
b1 = Coefficient of passenger number.
b2 = Coefficient of KRL door opening and closing.

and conduct several tests including validity and reliability tests, classical assumption tests, and hypothesis testing.

4 Research Results

Regression analysis shows the Table 2:

Table 2. Multiple Linear Regression Analysis Results

Coefficients						
Model		*Unstandardized Coefficients*		*Standardized Coefficients*	T	Sig.
		B	*Std. Error*	Beta		
1	*(Constant)*	22.752	.621		36.608	.000
	Number of Passengers	.025	.004	.655	6.004	.000
	Open and Close Doors	.015	.006	.268	2.456	.019

A. Dependen Variabel: Temperature Change in KRL

Table 3. T-test Results

Coefficients						
Model		*Unstandardized Coefficients*		*Standardized Coefficients*	T	Sig.
		B	*Std. Error*	Beta		
1	*(Constant)*	22.752	.621		36.608	.000
	Number of Passengers	.025	.004	.655	6.004	.000
	Open and Close Doors	.015	.006	.268	2.456	.019

A. Dependen Variabel: Temperature Change in KRL

This results in the following equation:

$$\mathbf{Y = 22,752 + 0,025X1 + 0,015X2}$$

From the multiple linear regression model equation, both the constant, variable X1, and X2 are positive. This means that the direction of the multiple linear regression model has a unidirectional relationship between variable X and variable Y, which means that the increasing number of passengers and the duration of door opening will also increase the temperature inside the KRL.

It can be seen from Table 3 that the t count and significance for each variable is the number of passengers of 6.004 and 0.000 for the duration of door opening and closing of 2.456 and 0.019. By looking at the numbers in the sig table that show numbers below 0.05, it means that both the number of passengers and door opening and closing have a partial significant effect on changes in temperature in the KRL room.

Table 4. F-count Results

ANOVA[a]						
Model		*Sum of Squares*	df	*Mean Square*	F	Sig.
1	*Regression*	21.539	2	10.769	**36.907**	.000[b]
	Residual	10.505	36	.292		
	Total	32.044	38			

A. Dependen Variabel: Temperature Change in *KRL*
B. *Predictors*: (*Constant*), Duration of Open and Close Doors, Number of Passengers

Table 5. Results of the Coefficient of Determination

Model Summary				
Model	R	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.820	.672	.654	.54019

a. *Predictors*: (*Constant*), Open and Close Doors, Number of Passengers
b. Dependen Variabel: Temperature Change in KRL

From the Table 4, it can be seen that the F test results are the calculated F value of 36,907 and a significance value of 0.000. This shows that all independent variables, namely the number of passengers and the duration of door opening and closing, have a significant effect simultaneously (together) on changes in temperature in the KRL room.

4.1 Effect of Variable X on Variable Y

The coefficient of determination (R square) of multiple regression results shows how much variable Y (temperature change in the KRL room) is influenced by variable X (number of passengers and duration of door opening and closing). The results of the coefficient of determination test can be seen in the Table 5:

Based on the data that has been processed with the help of the SPSS application, information is obtained about the magnitude of the influence of all independent variables on the dependent variable. The effect is symbolized by R (correlation). As seen in the model summary table, the value in the R column is 0.820, meaning that the influence of the variable number of passengers and the duration of door opening and closing on changes in temperature in the KRL is 82%, but this value can be said to be "contaminated" by various confounding values or errors that cause measurement errors, for that SPSS provides an alternative R Square value as a comparison of the accuracy of its influence.

It can be seen that the R Square value is 0.672, which means 67.2%. This value is smaller than the R value due to the adjustment. However, this value is not necessarily always smaller than the R value, but can be greater. This shows that 67.2% of the temperature change in the KRL room is influenced by the variable number of passengers and the duration of door opening and closing. While 32.8% is influenced by other variables that are not included in this research model.

Table 6. Correlation Test Results

Correlations		
		Temperature Change
Pearson Correlation	Temperature Change	1.000
	Number of Passengers	**.786**
	Open and Close Doors	**.586**
Sig. (1-*tailed*)	Temperature	.
	Number of Passengers	.000
	Open and Close Doors	.000
N	Temperature	39
	Number of Passengers	39
	Open and Close Doors	39

Table 7. Substitution Value of SE and SR Contributions

Variabel	Regression Coefficient (Beta)	Correlation Coefficient (R)	R *Square*
X1	0,655	0,786	67,2
X2	0,268	0,586	

4.2 Predictor Contribution

This test is used to determine the size of how much influence the independent variable has on the dependent variable in multiple linear regression analysis. The calculation of effective contribution and relative contribution is consistent with the Beta value and correlation coefficient in the SPSS output. The following is a table of correlation test results used to determine the effective contribution value of a multiple linear regression model.

From the Table 6, it is known that the correlation coefficient X1 is 0.786 and the coefficient X2 is 0.586. Furthermore, a table is made to describe the value needed to determine the effective contribution and relative contribution (Table 7).

Effective contribution of variable X1 to Y

$$\begin{aligned} \text{SE(X1)\%} &= \text{Beta X1} \times \text{Correlation Coefficient X1} \times 100\% \\ &= 0,655 \times 0,786 \times 100\% \\ &= 51{,}5\% \end{aligned}$$

Table 8. Calculation Results of SE and SR

No	Nama Variabel	Contribution	
		Effective	Relative
1.	Number of Passengers (X1)	51,5%	77%
2.	Duration of Open and Close Doors (X2)	15,7%	23%
Total		67,2%	100%

Effective contribution of variable X2 to Y

$$\begin{aligned} \text{SE(X2)\%} &= \text{Beta X2} \times \text{Correlation Coefficient X2} \times 100\% \\ &= 0,268 \times 0,586 \times 100\% \\ &= 15{,}7\% \end{aligned}$$

So the effective contribution of the two predictors is 51.5% from predictor X1 and 15.7% from predictor X2.

The next step is to calculate the relative contribution which is used to determine the amount of contribution of each predictor, which is expressed in percentages where, the total SR of all predictors is 100% (Table 8).

From the results of the above calculations, it can be concluded that the effective contribution (SE) of the two variables in this study is 67.2%. The variable number of passengers is 51.5% and the variable duration of door opening and closing is 15.7% while the remaining 32.8% is influenced by other factors not examined in this study. While the relative contribution of the two variables, namely the variable number of passengers (X1) to changes in temperature on the KRL (Y) of 77% and the variable duration of door opening and closing (X2) to changes in temperature on the KRL (Y) of 23%. So that the total relative contribution is 100%. This shows that the number of passengers variable has the largest relative contribution to temperature changes on the KRL.

5 Conclusion

This study aims to determine the effect of the number of passengers and the duration of door opening and closing on changes in temperature in the KRL room. Based on the data that has been obtained from the test results carried out using the multiple linear regression analysis method, the following conclusions can be drawn:

a. All independent variables, namely the number of passengers and the duration of door opening and closing, have a significant effect partially on changes in temperature in the KRL room as evidenced by the t test, and all independent variables, namely the number of passengers and the duration of door opening and closing, have a significant effect simultaneously (together) on changes in temperature in the KRL room. This is evidenced by the anova test.

b. The temperature change in the KRL is 67.2% influenced by the variable number of passengers and the number of door closures, while 32.8% is caused by other variables not included in this study.

References

1. Wright, L., & Fjellstrom, K. Mass Transit Options. Eschborn: Gesellschaft für Technische Zusammenarbeit (GTZ). 2003
2. Ahmadi, T. A. Evaluasi Layanan Transportasi Publik Kereta Rel Listrik Commuter Line Di Jabodetabek. Semarang: Universitas Negeri Semarang. 2019
3. Tambunan, E. Analisis Kualitas Pelayanan Ka Commuter Line Rute Parungpanjang-Tanah Abang. e-Journal CENTECH 2020 Vol. 1, 10. 2020
4. Wijayanto, H. Peranan Penggunaan Transportasi Publik di Perkotaan (Studi Kasus Penggunaan Kereta Commuterline Indonesia Rute Jakarta-Bekasi). Jurnal Studi Kepemerintahan, 8. 2019
5. Yohanes, P. T .Analisis Temperatur Dan Sistem Pengkondisian Udara Pada Kereta Eksekutif Malam Bangunkarta. Surabaya: Institut Teknologi Sepuluh Nopember. 2015
6. Fuady, F. Evaluasi Beban Pendingin Dan Peluang Penghematan Di Lantai Iv Dan Vi Universitas Xyz. 2017
7. Setyawan, I. Penerapan Prinsip Perhitungan Beban Kalor Pada Ruangan. Yogayakarta: Universitas Gajah Mada. 2019
8. Seriani, S., Fernandez, R., Luangboriboong, N., & Fujiyama, T. Exploring the Effect of Boarding and Alighting Ratio on Passengers' Behaviour at Metro Stations by Laboratory Experiments. Journal of Advanced Transportation, 12. 2019
9. Zheng, W., Wen, X., Cai, J., & Chongxiao Li, D. H. Characteristics of thermal environment influenced by the opening and closing of a subway train sliding door. Case Studies in Thermal Engineering, 19. 2021